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CONTENTS

ABSTRACT

Building and Fire Research Publications, 1996 contains references to the publications prepared by the members of the Building and Fire Research Laboratory (BFRL) staff, by other National Institute of Standards and Technology (NIST) personnel for BFRL, or by external laboratories under contract or grant from the BFRL during the calendar year 1996.

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I. LITERATURE CITATIONS ARRANGED BY FIRST AUTHOR

A

Andrus, R. D.; Chung, R. M.
Cost-Effective Ground Improvement for Liquefaction Remediation Near Existing Lifelines.
National Institute of Standards and Technology, Gaithersburg, MD
U.S./Japan Cooperative Program in Natural Resources. Panel on Wind and Seismic Effects. Joint Meeting, 27th. Proceedings. May 16-19, 1995, Tsukuma, Japan, 115-123 pp, 1995.

lifelines; building technology; earthquakes; ground improvement; permanent ground deformation; soil liquefaction

Little information has been gathered on ground improvement near existing lifelines. Five low vibration ground improvement techniques suitable for remedial work near existing structures are discussed. The five techniques are: compaction grouting, permeation grouting, jet grouting, in situ soil mixing, and drain pile. Cost estimates are given for each technique, except the drain pile technique which is not yet available in the United States. Two reported case histories of ground improvement near buried pipes and conduits are reviewed. A combination of techniques may provide a cost-effective solution for preventing damage to existing lifelines resulting from liquefaction-induced horizontal ground displacement, subsidence, and uplift.

Andrus, R. D.; Chung, R. M.
Liquefaction Remediation Near Existing Lifeline Structures.
National Institute of Standards and Technology, Gaithersburg, MD
Technical Report NCEER-96-0012; NCEER Task Number 95-2702A; Japan/U.S. Workshop on Earthquake Resistant Design of Lifeline Facilities and Countermeasures Against Soil Liquefaction, 6th Proceedings. National Center for Earthquake Engineering Research. June 11-13, 1996, Tokyo, Japan, National Center for Earthquake Engg. Res., NY, Hamada, M.; O'Rourke, T., Editors, 457-476 pp, 1996.

earthquakes; building technology; ground improvement; lifelines; permanent ground deformation; soil liquefaction

Organized and systematic studies on the phenomenon of liquefaction began after the 1964 Niigata earthquake. Great progress has been made through research, much of it conducted by researchers in Japan and U.S., to develop a fundamental understanding of the mechanism of liquefaction. A number of in-situ ground improvement methods have been developed to reduce the vulnerability of ground susceptible to liquefaction. Many of these methods were developed empirically, and some are very costly to implement. This paper examines the critical factors that influence the effectiveness of five ground improvement techniques which are most suitable for remedial work near existing lifeline structures. Expected cost of using these methods are given, even though the cost data from cases examined is scarce. Advantages and constraints of each of these methods are presented. Eight case histories of remedial work near existing lifeline structures are reviewed.

Andrus, R. D.; Stokoe, K. H., II
Preliminary Guidelines for Liquefaction Assessment Using Shear Wave Velocity.
National Institute of Standards and Technology, Gaithersburg, MD
University of Texas, Austin
NIST SP 904; August 1996.

U.S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U.S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 28th. May 14-17, 1996, Gaithersburg, MD, Raufaste, N. J.,
Editor, 77-83 pp, 1996.
Available from Government Printing Office
SN003-003-03424-0
Available from National Technical Information Service
PB97-104376

building technology; earthquake engineering; in situ measurements; seismic testing; shear wave velocity; soil liquefaction

This paper presents preliminary guidelines for assessing the liquefaction resistance of soils using small-strain shear wave velocity. The guidelines are based on field performance data from 17 earthquakes and in situ shear wave velocity measurements at over 40 different sites in soils ranging from sandy gravel with cobbles to profiles including silty clay layers. Additional data are needed from denser soil sites shaken by stronger ground motions to further validate the proposed liquefaction potential boundaries.

Arnold, J. A.; Teicholz, P.
Study of the Life Cycle Requirements for an Information Model of the Components That Are Incorporated in Process Facilities.
Stanford Research Inst., Menlo Park, CA
NIST-GCR-96-705; 122 p. March 1996.
Available from National Technical Information Service
PB97-129589

research facilities; life cycle

This paper reports the results of research that explores product modeling issues for components that are incorporated in process plant facilities. This project begins with an information requirements study that identifies the industry stake holders, the business and technical processes involved in component information exchange, and the life-cycle information requirements of a typical process plant component, the control valve. The findings for the study are described through a review of the business issues, and through a process description of the "life-cycle" of a valve within a hypothetical project context. Through this case study, the research attempts to identify data and engineering knowledge that should be included in a component information model to support and improve business process. In the final phase of the project, an information model and component selection test case for one component type is developed. Based upon the results of the information requirements study, the test case explores the integration of an explicit description of product data (including form, function, and behavior) and a task based process in a component information model. This model provides support for analysis and evaluation of component selection in an intelligent engineering application. It is proposed that the integration of product and process description in a component information model makes it possible to develop information exchange technologies that can effectively support and improve business process. This approach is compared to other efforts that are being pursued within the research community and industry, e.g., the STEP/EXPRESS initiative and related efforts.

Auzerais, F. M.; Dunsmuir, J.; Ferreol, B. B.; Martys, N. S.; Olson, J.; Ramakrishnan, T. S.; Rothman, D. H.; Schwartz, L. M.
Transport in Sandstone: A Study Based on Three Dimensional Microtomography.
Schlumberger-Doll Research, Ridgefield, CT
Exxon Research and Engineering Co., Annandale, NJ
Massachusetts Institute of Technology, Cambridge
National Institute of Standards and Technology, Gaithersburg, MD

Geophysical Research Letters, Vol. 23, No. 7, 705-708, April 1, 1996.

microtomography; transport; permeability; conductivity; porous media; building technology

High resolution imaging of the microstructure of Fontainebleau sandstone allows a direct comparison between theoretical calculations and laboratory measurements. While porosity, pore-volume-to-surface ratio, permeability, and end point relative permeability are well predicted by our calculations, we find that electrical resistivity and wetting phase residual saturation are both overestimated.

B

Babushok, V.; Noto, T.; Burgess, D. R. F.; Hamins, A.; Tsang, W.
Influence of CF3I, CF3Br, and CF3H on the High-Temperature Combustion of Methane.
Institute of Chemical Kinetics and Combustion, Novosibirsk, Russia
NKK Corp., Kawasaki, Japan
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 107, No. 4, 351-367, December 1996.

methane; high temperature; combustion; kinetics; validation; temperature effect; ignition delay; reaction time; additives

The effects of a number of flame retardants (CF3I, CF3Br, and CF3H) on the high-temperature reactions of methane with air in a plug flow reactor are studied by numerical simulations using the Sandia Chemkin Code. The dependence of (a) the ignition dely and (b) time for substantially complete reaction as a function of temperature and additive concentrations are calculated. In agreement with experiments, the ignition delay can be increased or decreased by the addition of retardants. The reaction time is always increased by additives. The mechanism for these effects has been examined. It is concluded that the ignition delay is controlled by the initial retardant decomposition kinetics, which releases active species into the system. These species can either terminate or initiate chains. The reaction time is largely a function of the concentrations of the active radicals H, OH, and O that are formed during the combustion process. It is shown that their concentrations, particularly those of H atoms, are lowered in the presence of the retardants. We find that the chemical mechanism governing reaction time is very similar to that which controls the flame velocity and a correlation between decreases in flame velocity and H-atom concentration is demonstrated. The calculations suggest that relative reaction time and H-atom concentrations should be effective measures for the estimation of retardant effectiveness.

Babushok, V.; Noto, T.; Hamins, A.; Tsang, W.
Computations of Inhibition Effectiveness of Halogenated Compounds in Premixed Flames.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 55-56 pp, 1996.
Available from National Technical Information Service

fire research; fire science; premixed flames; halogenated compounds; burning velocity; flame structure

The burning velocity is an important parameter which characterizes the inhibition efficiency of halon-containing additives employed as flame retardants. The burning velocity decreased with increasing inhibitor concentration. Rosser et al. studied experimentally the inhibition effect of different additives on methane flames and found that the burning velocity decreased linearly with increasing additive concentration for concentrations less than 0.5% by volume. In addition, Rosser et al. used the parameter [see report] as a measure of inhibition efficiency.

Baum, H. R.; McGrattan, K. B.; Rehm, R. G.
Large Eddy Simulations of Smoke Movement in Three Dimensions.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 189-198 pp, 1996.

fire safety; smoke measurement; simulation; mathematical models; equations; smoke transport; high temperature gases; enclosures

This paper describes a methodology for simulating the transport of smoke and hot gases in enclosures. The approach is based on the use of efficient CFD techniques and high performance computers to solve a form of the Navier Stokes equations specialized to the smoke movement problem. The fire is prescribed in a manner consistent with a mixture fraction based approach to combustion, but the combustion phenomena themselves are not simulated. The mixing and transport of smoke and hot gases is calculated directly from an approximate form of the Navier Stokes equations. The computations are carried out as a three-dimensional time-dependent process, limited only by the spatial resolution of the underlying grid. No turbulence models are employed; the large scale eddies are simulated directly and sub-grid scale motions are suppressed. Present capabilities permit a typical residential room or hotel unit to be simulated at a 3-5 centimeter resolution limit, with correspondingly coarser resolution for larger spaces. The enclosure can have any shape made up of rectangular blocks, and can be multiply connected. The smoke is simulated by tracking a large number of Lagrangian elements, which originate in the fire. These same elements carry the heat released by the fire, providing a self consistent description of the smoke transport at all resolvable length and time scales. Large temperature and pressure variations are permitted, subject to the limitation that the Mach Number is much less than one. The next two sections give a brief description of the mathematical and computational aspects of the model, while the final section illustrates its capability with sample results and a comparison with experiment.

Baum, R. T.; McGrattan, K. B.; Nyden, M. R.
Distributed Detection for Tomographic Measurements of Component Concentrations in Fire Generated Plumes.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 125-126 pp, 1996.
Available from National Technical Information Service

fire research; fire science; fire plumes; fire models; flow fields; turbulent flow; validation

One of the major goals of fire research is to develop the capability to make realistic assessments of fire impact and risk by utilizing models. Currently the large scale fire/plume models may not be validated and hence calculations which may have a large economic/safety impact may be considered suspect. As a consequence, these models are under utilized. In order to increase the level of confidence placed in these computational models to an acceptable level a rigorous experimental tomographic validation technique has been under development at BFRL/NIST. In the pursuit, we have analyzed data from both laboratory and computer generated plumes in order to determine the number of line-of-sight measurements, the detector topology and the temporal resolution needed to obtain accurate tomographic reconstructions of the component concentrations in asymmetric turbulent flow fields.

Beall, K., Editor
Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; 163 p. October 1996.

National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, Beall, K., Editor, 1996.
Available from National Technical Information Service

fire research; fire science; fire suppression; water sprays; soot; pool fires; jet fires; halon alternatives; fire plumes; fire detection; toxic gases; flammability

The NIST Annual Conference on Fire Research has long been the prime forum for presentation and discussion of the latest advances in the science of fire and the engineering of fire safety. Hundreds of billions of dollars of products and services are involved in fire safety decisions each year. New technology is changing the way those products are developed, manufactured, evaluated, and used. This conference enables all interested parties to hear of and discuss advances in fire science, with the intent of stimulating (a) new products that are more fire-safe and (b) new ways to capture that value in the ways products are for use. The conference scope includes all fire research performed within Federal laboratories or sponsored by Federal agencies, as well as work from laboratories around the world. This booklet contains the abstracts of the 76 papers focussing on the phenomenology of fire: fire extinguishment, chemistry and physics of material and product combustion, flame spread, flame structure, soot, pool fires, fire-induced flows, fire plumes, combustion product generation and measurement, and fire detection. Discussion session will consider the status of our knowledge and the most important understanding yet to be developed. With this, we hope to continue cross-pollinating the elements of the fire research community while stimulating our members to new understanding that will lead to more fire-safe products and practices.

Benedict, L.; Zukoski, E. E.
Buoyant Flows in Shafts.
California Institute of Technology, Pasadena, CA
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 69-70 pp, 1996.
Available from National Technical Information Service

fire research; fire science; buoyant flow; stack effect; temperature fields; heat transfer; walls

The motions of buoyant flows contained within vertical shafts are being investigated in an experimental program that will lead to a prediction of the transport of heat and toxic materials within shafts due to buoyancy controlled mixing and the stack effect when the influence of heat transfer to the walls of the shaft can not be neglected. This work is based in part on the earlier experiments of Cannon, J. B. and Zukoski, E. E. In this program, the basic flow under investigation is the motion of hot air within a vertical shaft and the subsequent heat transfer when the shaft is completely closed except at the bottom.

Bentz, D. P.; Clifton, J. R.; Synder, K. A.
Prototype Computer-Integrated Knowledge System: Predicting Service Life of Chloride-Exposed Steel-Reinforced Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
Concrete International, 42-47, December 1996.

reinforced concretes; service life; steels; computer models; databases

In the last decade or so, numerous advances have occurred in the field of information technology. Through the use of computers, the amount of available information and the speed at which it can be retrieved have both increased dramatically. The proliferation of the Internet and the World Wide Web (WWW) now allows researchers to rapidly access a wealth of multimedia information on a seemingly infinite variety of topics. The World Wide Web also provides a convenient format for executing computer programs over the Internet, for example through the use of forms and common gateway interface (CGI) scripts or other Internet programming languages.

Bentz, D. P.; Garboczi, E. J.
Digital-Image-Based Computer Modeling and Visualization of Cement-Based Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Emerging Technologies in Geotechnical Engineering. Transportation Research Record No. 1526. Soils, Geology, and Foundations. Proceedings. Transportation Research Board.
Proceedings. January 1996, National Academy Press, Washington, DC, 129-134 pp, 1996.
building technology; cement-based materials; computer models; diffusivity; digital images; interfacial transition zone; microstructure; visualization

Over the past several years, digital-image-based computer models and subsequent visualization of microstructure have proven valuable in studying processing-mirostructure-property relationships in cement-based materials. This paper reviews the computer modeling techniques used to simulate the microstructure of hydrating cement paste at the micrometer level and the microstructure of concrete and mortar at the millimeter level. In the former case, digital-image-based models using cellular automata offer many advantages in simulating the reactions occurring during the hydration of cement paste. In the latter case, a continuum hard core-soft shell percolation model appears to be most efficient for modeling the aggregates in a mortar or concrete, each surrounded by an interfacial transition zone (ITZ). Here, digitization is employed to compute the volume fractions occupied by aggregate, bulk cement paste, and ITZ cement paste. The influence of microstructure on the diffusivity of these materials is addressed within the overall framework of this multiscale modeling approach.

Bentz, D. P.; Garboczi, E. J.; Martys, N. S.
Application of Digital-Image-Based Models to Microstructure, Transport Properties, and Degradation of Cement-Based Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Modelling of Microstructure and Its Potential for Studying Transport Properties and Durability. 1996, Kluwer Academic Publishers, Jennings, H., Editor, 167-185 pp, 1996.
building technology; cements; cement based materials; computer models; microstructure; transport properties; degradation

As multi-phase composites, cement-based materials have physical properties that are strongly influenced by the volume fractions and topologies of the individual phases. Because of their inherent random nature, these materials often defy a simple geometrical description. The use of digital-image-based models allows one to realistically represent this class of materials, as resultant microstructures can be quickly quantified with respect to the volume fraction and interconnectivity or percolation of each phase or any combination of phases. In addition, physical properties such as diffusivity and permeability can be conveniently computed using finite-difference or finite-element techniques. These computer modeling techniques will be demonstrated for microstructural models of these materials at two scales: hydrated cement paste at the micrometer level and calcium silicate hydrate gel at the nanometer level. The properties computed for the gel at the nanometer level can be used as input for the micrometer-level model. Examples of the importance of volume fraction and phase topology in determining physical properties will be presented for each of the four major phases of cement paste: anhydrous cement, capillary porosity, calcium silicate hydrate gel, and calcium hydroxide. Results of the models are compared to existing experimental data, and good agreement is observed. These techniques are seen as one critical link in developing sound scientific relationships between the microstructure and the transport properties and durability of cement-based materials.

Boocock, S. K.; Kaetzel, L. J.
Coating Industry Knowledge Base Systems.
SSPC, Pittsburgh, PA
National Institute of Standards and Technology, Gaithersburg, MD
Steel Structures Painting Council (SSPC). Technologies for a Diverse Industry. SSPC 1996 Seminars. Proceedings. SSPC 96-08. November 17-21, 1996, Charlotte, NC, 144-149 pp, 1996.

coatings; industries; decision making; construction; computer programs; expert systems

This presentation provides information about the proposed SSPC Coatings Knowledge Center and activities of a national program for a computer integrated knowledge systems network administered by the National Institute of Standards and Technology.

Boyd, C. F.; diMarzo, M.
Fire Protection Foam Behavior in a Radiative Environment.
September 1995-September 1996.
Maryland Univ., College Park
NIST-GCR-96-702; 182 p. October 1996.
Available from National Technical Information Service
PB97-116131

foam extinguishing systems; foam expansion; computer models; fire protection; fire research; heat flux; heat radiation; insulation; temperature profiles; equations

A model is developed which predicts the behavior of a fire-protection foam subjected to heat radiation. Foam expansion ratio and radiative heat flux are input to the model. A mass and energy balance yield the foam destruction rate and the temperature distribution within the foam. The model separates the foam into its liquid, vapor, and air components. Continuity is satisfied for each. Ideal gas relations, a realistic density function, and foam expansion measurements are used in conjunction with continuity to compute the volume fraction and velocity of each component as a function of temperature. The energy equation is solved in a coordinate system moving with the foam front. Separate air, vapor, and liquid convection terms are computed. Radiation absorption is accounted for with a volumetric generation term. The absorption model is based upon experimental measurements. A volumetric evaporative term accounts for the latent heat of liquid vaporized within the foam. Liquid vaporization rates are determined from the liquid continuity equation. Saturated conditions and thermodynamic equilibrium are assumed throughout. Thermal diffusion is computed using an experimentally determined thermal conductivity. A steady state solution is computed with a second order Crank-Nicolson technique. Fixed values for the temperature at the evaporative front and in the far field are used as boundary conditions. Dimensionless results indicate the major terms in the energy balance are proportional to applied heat flux. The dimensionless temperature gradient in the near linear range of the profiles collapses to a single value.

Boyd, C. F.; diMarzo, M.
Numerical Model and Experimental Results of Fire Protection Foam Exposed to Heat Radiation.
Nuclear Regulatory Commission, Washington, DC
Maryland Univ., College Park
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 141-142 pp, 1996.
Available from National Technical Information Service

fire research; fire science; thermal radiation; fire fighting; structures; foam extinguishing systems; fire damage; fire protection; scaling

This work is part of a larger effort to evaluate the performance of fire-fighting agents used to protect structures from heat and fire damage. A joint research program between the University of Maryland and the Building and Fire Research Laboratory at the National Institute of Standards and Technology supported this effort. The present research looks at fire-fighting

Brannigan, V.; Smidts, C.; Kilpatrick, A.
Regulatory Requirements for Performance Based Codes Using Mathematical Risk Assessment.
Maryland Univ., College Park
Caledonian Univ., Glasgow, Scotland
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 621-630 pp, 1996.

fire safety; risk assessment; codes; regulations; nuclear power plants; mathematical models

Fire safety is one of the most complex and difficult areas proposed for the use of risk assessment and performance based codes. Mathematical risk assessment involves the use of probabilistic models of real world events. However, fire is a rare and complex event for which significant uncertainties exist. Fire safety regulators are often unsophisticated, and code enforcement is fragmented. Current fire safety regulatory systems assume static buildings with ample safety reserves. From a legal perspective, uncertainity is resolved by political, not technical decision making. All these factors argue for a high level of scrutiny of mathematical risk models used for performance based regulation. Technological regulation involves predicting and anticipating technological failures. Compliance with regulations should be connected to a reduction in the risk of injury and mathematical risk models can be used to predict accidents and develop performance based codes. However, regulation is a process in which parties prove that their designs are in compliance with social norms, and it is unclear what standard of proof for mathematical risk models is appropriate. Minimum regulatory standards must be developed for mathematical risk models used to support performance based codes.

Brown, J. E.; Kashiwagi, T.
Gas Phase Oxygen Effect on Chain Scission and Monomer Content in Bulk Poly(Methyl Methacrylate) Degraded by External Thermal Radiation.
National Institute of Standards and Technology, Gaithersburg, MD
Polymer Degradation and Stability, Vol. 52, 1-10, 1996.

chain scission; decomposition; gasification; molecular weight; polymethyl methacrylate; size exclusion chromotography; thermal degradation; thermal oxidation

The effect of the atmosphere oxygen on the thermal decomposition of poly(methyl methacrylate), PMMA, in a slab-like configuration was investigated. Blackbody irradiation of 12 mm thick PMMA slabs on one side was used to simulate the thermal decomposition and gasification of the polymer in a fire environment. Results are reported for chain scission number obtained from molecular weight measurements and for residual monomer content at various levels below the slab surfaces irradiated at 17 and 30 kW/m2 in atmospheres containing 0, 10, 21, and 41% oxygen in nitrogen. The scission number and polydispersity of surface layers, about 0.1 mm thick, were found to increase linearly with the mole fraction of oxygen in nitrogen. Over this range (0 to 41% O2) the scission number increased from 1.5 to 5.0 and the polydispersity increased from 3.6 to 11.3 when the PMMA was degraded at the lower flux, while at the higher flux, the scission number increased from 5.0 to 14.4 with a concomitant polydispersity change from 2.0 to 4.5. These results show that gas phase O2 reacts with the polymer chains, enhancing random scissions and generating functional groups from which depropagation is initiated. This enhanced decomposition increases the transient gasification rate leading to ignition and flame spread.

Bukowski, R. W.
Applications of FASTLite.
National Institute of Standards and Technology, Gaithersburg, MD
Society of Fire Protection Engineers and WPI Center for Firesafety Studies. Computer Applications in Fire Protection Engineering. Technical Symposium. Proceedings. Final Program. June 20-21, 1996, Worcester, MA, 59-66 pp, 1996.

fire protection engineering; egress; evacuation time; fire growth; fire hazards assessment; fire models; smoke filling

The use of computer supported fire safety engineering calculations has grown significantly in recent years. One of the early, favorite tools of the fire protection engineer was FIREFORM and later FPEtool, both of which were developed by Bud Nelson. Now NIST has release FASTLite, the successor to these programs. FASTLite retains the set of simple algebraic equations of FIREFORM, but replaces the single room fire model FIRE SIMULATOR with a (maximum) three room version of CFAST modified to provide the operational features of FIRE SIMULATOR which users have come to depend on. These include simple construction of heat release rate curves, pauses in execution to allow modification of the scenario specification, and automatic output in selectable engineering units; all with the faster-than-real-time excuation speeds of the former model. The platform for these developments is CFAST. By integrating the CFAST zone model into FASTLite prior work on its validation and accuracy assessment is applicable and it is possible to add technical improvements to FASTLite, CFAST, and HAZARD as a single family of models. FASTLite also becomes entirely compatible with the others so that users who begin an analysis with FASTLite can build on the same basic input file by adding additional compartments or features supported in CFAST, such as HVAC modeling.

Bukowski, R. W.
Fire Risk or Fire Hazard as the Basis for Building Fire Safety Performance Evaluation. [Fire Risk or Fire Hazard - Building Fire Safety.]
National Institute of Standards and Technology, Gaithersburg, MD
Institut de Securite. Fire Safety Conference on Performance Based Concepts. Proceedings. October 15-17, 1996, Zurich, Switzerland, 18/1-10 pp, 1996.

fire safety; fire codes; building codes; standards; life safety; performance codes; risk assessment; scenarios

Nearly every developed country has committed to the goal of a performance-based code by early in the next century. Most have expressed interest in the use of fire risk assessment as the means to judge performance against the code's explicit objectives. The fact that risk can never be eliminated may lead to the public perception that officials feel a few deaths are somehow acceptable. Risk of financial loss is easier to understand but is difficult to apply to life safety concerns without becoming embroiled in the value of life. Since a rigorous risk assessment is computationally intense and requires a vast amount of historical data that is frequently not collected, most analyses conducted in support of performance evaluation are hazard assessments. These measure performance in a specified set of conditions which are presumed to represent the principal threats. Since experience has shown that the worst fires are the result of many things going wrong together, it is desirable to account for situations characterized by multiple failures in providing for the safety of the public. The purpose of this paper is to identify research issues to be addressed by international programs such as the CIB W14 Task Group on Engineering Evaluation of Building Fire Performance.

Bukowski, R. W.
Fire Safety Engineering in the Pursuit of Performance-Based Codes: Collected Papers.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5878; 111 p. October 1996.
Available from National Technical Information Service
PB96-114482

fire codes; life safety; performance codes; risk assessment; fire safety; safety engineering; scenarios

The technical and philosophical basis for performance-based assessment of building fire performance is reviewed. A strategy for the evolution of a performance code is described. Current efforts toward the development of performance codes in the United States and Japan are reviewed. Recommendations for critical steps necessary to advance the development and acceptance of performance codes are presented. The table of contents of the Japanese risk methodology for assessing "Article 38 equivalencies" is included in an appendix.

Bukowski, R. W.
Hazard II: Implementation for Fire Safety Engineering.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Design of Buildings and Fire Safety Engineering. Conference Compendium. Proceedings. Session 3: Fire Safety Engineering Tools. August 19-20, 1996, Oslo, Norway, 1-7 pp, 1996.

fire safety; building codes; safety engineering; fire research; egress; evacuation time; fire growth; fire hazards; hazard assessment; fire models; smoke filling

Much of the world is engaged in the transition from prescriptive codes to performance-based codes for the regulation of safety in the built environment. The motivation for these changes is the concept that sensible regulations lead to improved flexibility of design and lower costs for no reduction in safety. In such a construction climate it is easier to attract international business development with its attendant jobs and growth of the tax base, especially in these times of the global marketplace. This paper presents a vision of the futuer development of HAZARD I and its primary components in the context of its application to fire safety engineering analysis supporting performance-based codes.

Bukowski, R. W.
Modelling a Backdraft Incident: The 62 Watts Street (New York) Fire.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Engineers Journal, Vol. 56, No. 185, 14-17, November 1996.

fire safety; safety engineering; backdraft; fire fatalities; fire fighters; fire models; apartments; smoke; heat release rate; oxygen concentration; temperature; computer models; casualties; smoke; ventilation; building fires

On March 28, 1994, the New York City Fire Department responded to a report of smoke and sparks issuing from a chimney at a three-story apartment building in Manhattan. The officer in charge ordered three person hose teams to make entry into the first and second floor apartments while the truck company ventilated the stairway from the roof. When the door to the first floor apartment was forced open, a large flame issued from the apartment and up the stairway, engulfing the three fire fighters at the second-floor landing. The flame persisted for at least 6 1/2 minutes, resulting in their deaths. The FDNY requested the assistance of the National Institute of Standards and Technology (NIST) to model the incident in the hope of understanding the factors which produced a backdraft condition of such a duration. The CFAST model was able to reproduce the observed conditions and supported a theory of the accumulation of significant quantities of unburned fuel from a vitiated fire in an apartment which had been insulated and sealed for energy efficiency.

Bukowski, R. W.
Risk and Performance Standards.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Risk and Hazard Assessment Symposium: Research and Practice - Bridging the Gap. Proceedings. National Fire Protection Research Foundation. June 26-28, 1996, San Francisco, CA, 37-45 pp, 1996.

fire risk; hazard assessment; standards; fire codes; life safety; codes; risk assessment; scenarios

Performance codes are replacing prescriptive codes in much of the world. As the form of the codes change, the form of standards which support those codes needs to evolve in concert. Thus, performance standards need to be explicit about the purpose(s) served by the standardized systems and to provide quantitative means to assess the degree to which they serve that purpose. Most of the engineering methods evolving to support performance based codes assess risk to life of building occupants relative to the risk to occupants in buildings which comply with the prescriptive code. Such relative risk assessment is cumbersome and unreliable, and should be replaced by absolute risk limits to enjoy all of the efficiencies of performance codes. Financial risk is easy to understand but is inappropriate to codes that exist to protect life. Risk to life is difficult to understand

and communicate to the public. These risk analysis methods utilize scenarios as a bridge to experience and the means to quantify likelihoods. In the absence of incident data some systematic methods of identifying scenarios is needed. This paper deals with each of these issues in an attempt to stimulate research needed to find the answers.

Bukowski, R. W.
Setting Performance Code Objectives: How Do We Decide What Performance the Codes Intend?
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 555-561 pp, 1996.
fire safety; codes; building codes; fire codes; safety factors

There is a worldwide movement toward the replacement of prescriptive codes with those based on performance against a set of clear and quantifiable objectives. This has sparked an important discussion of just what are appropriate objectives for society to demand of its built environment. Building codes have evolved well beyond their traditional roles of assuring the public health and welfare by incorporating requirements addressing social issues such as conservation and protection of heritage. In the fire codes, debate is ranging over whether people should be required to protect their own property from fire, and whether society can afford to protect all of the occupants and the fire service throughout any incident. Thus far, the discussion has been limited to identifying objectives, and has not yet turned to performance levels; a step that must be taken before performance codes can be implemented. Performance levels cannot simply be derived from current codes. Defining code objectives and performance levels in the United States presents a special challenge since these public policy issues must be debated by several model code groups, fifty state legislatures, and countless local bodies. NIST's role in the process is to provide the technical basis for the evaluation of performance against objectives, but not in setting the objectives nor their levels. However, since the code objectives in part determine the need for specific performance evaluation methods, NIST has an interest in facilitating the reaching of consensus on these difficult issues related to its role in the application of technology to maintaining U.S. competitiveness in world markets.

Bukowski, R. W.
What Every Chief Should Know About Performance-Based Codes.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Chief, Vol. 40, No. 12, 34-36, December 1996.
codes; fire departments

Many countries have made a formal commitment to implementing performance-based codes for regulating building fire safety. England, Wales, New Zealand, Australia, Sweden and Norway have performance-based regulations in place. Canada, Japan, Poland, Romania and China are actively restructing their regulations to embrace performance-based codes in the next three to five years.

Burch, D. M.; Tsongas, G. A.; Walton, G. N.
Mathematical Analysis of Practices to Control Moisture in the Roof Cavities of Manufactured Houses.
National Institute of Standards and Technology, Gaithersburg, MD
Portland State Univ., OR
NISTIR 5880; 60 p. September 1996.
Available from National Technical Information Service
PB97-106843

roofs; manufactured housing; moisture; air flow; attics; guidelines and practices; HUD standards; mathematical analysis; moisture analysis; moisture control; moisture modeling; roof cavities; climate; ventilation; ceiling vents

A mathematical model is presented that predicts moisture and heat transfer in ventilated cavities such as attics, roof cavities, and cathedral ceilings. The model performs a transient moisture and heat balance as a function of time of year and includes the storage of moisture and heat at the construction layers. The model includes both molecular diffusion and capillary transfer within the materials. Radiation exchange among the ventilated cavity surfaces is predicted using a mean-radiant-temperature-network model. Latent heat (i.e., the effect of water evaporating from one place and condensing at another place) is distributed within the materials. Airflow from the house into the ventilated cavity is predicted using a stack effect model with aggregated effective leakage areas. Air exchange between the ventilated cavity and outdoor environment is predicted by a semi-empirical model. The relative humidity in the house is permitted to vary during the winter and is calculated from a moisture balance of the whole building. This mathematical model was used to simulate the performance of a double-wide manufactured house constructed in compliance with the latest HUD Standards. An interior vapor retarder was installed in the ceiling construction and ventilation openings were installed in the roof cavity consistent with the 1/300 rule given in the HUD Standards. The effect of passive and mechanical ventilation, as well as a wide range of other factors on the roof sheathing moisture content was investigated as a function of time. The weekly average moisture content of the lower surface of the plywood sheathing was analyzed in several cold climates, while the relative humidity at the lower surface of the ceiling insulation was analyzed in a hot and humid climate. The analysis revealed the following: 1) airflow from the house into the roof cavity, as opposed to water-vapor diffusion, was the dominant moisture transport mechanism into the roof cavity; 2) high roof sheathing moisture content occurred in houses having high indoor relative humidity [i.e., high moisture production rate, or tight construction, or both]; 3) passive roof cavity vents consistent with the 1/300 rule were found to maintain the roof sheathing moisture content in non-humidified houses below fiber saturation during the winter; 4) the mechanical roof cavity ventilation rate specified in the HUD Standards for removing moisture during the winter was found to be too small and thus needs to be revised; 5) the presence of a ceiling vapor retarder was found to provide very small reductions in roof sheathing moisture content; 6) when an interior vapor retarder was installed in the ceiling construction of an air-conditioned house exposed to a hot and humid climate, the relative humidity at its upper surface rose above 80%, thereby providing a conducive environment for mold and mildew growth; and 7) the use of ceiling vents to provide additional whole house ventilation in cold climates substantially increased the roof sheathing moisture content of a house with an unventilated attic. Recommendations for further study are presented.

Bushby, S. T.

Testing Conformance and Interoperability of BACnet Building Automation Products.

National Institute of Standards and Technology, Gaithersburg, MD
CIBSE/ASHRAE Joint National Conference. September 28-October 1, 1996, Harrogate, UK, 1-7 pp, 1996.

BACnet; building automation; communication protocol; conformance testing; direct digital control

The BACnet standard defines classes of conformance and other collections of protocol functionality. Since a product need not support all of the capabilities of the protocol in order to conform to the standard, a manufacturer must select conformance classes and functional groups appropriate for the application the product is intended to meet. A system integrator must also understand these classifications in order to prepare procurement specifications. The standard does not contain test procedures for determining if a device conforms to the standard. In 1993 the NIST BACnet Interoperability Testing Consortium was formed, in part to develop procedures and tools to test the conformance and interoperability of BACnet products. This paper describes BACnet conformance classification issues and the work of the NIST consortium in developing testing tools and applying them to test products made by member companies.

Butler, K. M.
Analytical Model of Pyrolysis for a Finite Thickness Sample on a Semi-Infinite Base.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 103-104 pp, 1996.
Available from National Technical Information Service

fire research; fire science; thickness; pyrolysis; flammability tests; substrates; material properties

To test the flammability of materials, a sample is placed on a substrate and exposed to a uniform heat flux. Measurements include sample mass and upper and lower surface temperatures as functions of time. Several analytical models have been developed in an attempt to fully understand the relationship between properties of the tested materials and test results. Most of these models have assumed a semi-infinite sample, although the finite thickness of the sample is known to have a significant effect on pyrolysis behavior. An analytical solution that includes finite sample thickness and the material properties of the base is introduced in this abstract.

C

Caro, T. C.; Milke, J. A.
Survey of Fuel Loads in Contemporary Office Buildings.
Maryland Univ., College Park
NIST-GCR-96-697; 32 p. September 1996.
Available from National Technical Information Service
PB97-114235

office buildings; fuel loads; surveys; chairs; computers; furniture; interior furnishings; office furniture

The method, used in the latest study performed in 1975, for surveying offices to determine fuel load estimates is presented. The frequency distribution for the estimates of the fuel load found in the study are presented. Two methods for determining movable fuel load are utilized in this study. Moveable fuel load is considered to be the furniture, equipment, and other items brought in for the service of the occupants after construction of the building. Direct weighing techniques are utilized in both methods. In one method, the office contents are taken from their operational location and weighed. The second method, weighs the office contents when packaged for either relocation or remodeling purposes. Two types of offices were surveyed, open plan design and the traditional compartmented layout. Current offices are composed of large open plan spaces which are subdivided into office space or workstations by partitions. Also contributing to the fuel load are desktop computers which are common accessories. Surveys were conducted in buildings at the University of Maryland College Park and at the General Services Administration (GSA) Headquarters Building in Washington, D.C. Statistical results are presented for the two survey methods, each office type and each material category. The results of the study present the impact of open plan designs on the fuel load and also present the partition and computer accessory fuel load contributions. In addition, a comparison is made for the fuel load found at the University of Maryland, College Park and that found at GSA. The fuel load estimates for each office are separated into the following categories in order to group items of similar material composition: papers/books, computer equipment, furniture, partitions, and miscellaneous.

Chandra, S.; diMarzo, M.; Qiao, Y. M.; Tartarini, P.
Effect of Liquid-Solid Contact Angle on Droplet Evaporation.
University of Toronto, Ontario, Canada
Maryland Univ., College Park
Universita di Bologna, Italy
NIST-GCR-96-687; Paper 15; June 1996.
Available from National Technical Information Service
PB96-202304

water sprays; droplets; evaporation; stainless steels; experiments; computer models; water; hot surfaces; heat transfer; solid surfaces

The effect of varying initial liquid-solid contact angle on the evaporation of single droplets of water deposited on a stainless steel surface is studied using both experiments and numerical modeling. Contact angle is controlled in experiments by adding varying amounts of a surfactant to water. The evolution of contact angle and liquid-solid contact diameter is measured from a video record of droplet evaporation. The computer model is validated by comparison with experimental results. Reducing contact angle increases contact area between the droplet and solid surface, and also reduces droplet thickness, enhancing heat conduction through the droplet. Both effects increase droplet evaporation rate. Decreasing the initial contact angle from 90DG to 20DG reduces droplet evaporation time by approximately 50%. The computer model is used to calculate surface temperature and heat flux variation during droplet evaporation: reducing contact angle is shown to enhance surface cooling.

Chapman, R. E.; Fuller, S. K.
Benefits and Costs of Research: Two Case Studies in Building Technology.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5840; 109 p. July 1996.
Available from National Technical Information Service
PB96-202221

benefit cost analysis; building economics; building materials; construction; economic analysis; energy conservation; evaluation methods; research impacts

The National Institute of Standards and Technology (NIST) is improving its resource allocation process by doing "microstudies" of its research impacts on society. This report is the outgrowth of a series of microstudies prepared by NIST's Building and Fire Research Laboratory (BFRL). This report has four major purposes. First, it examines five evaluation methods for measuring the economic impacts of research investments. Second, it establishes a framework for identifying, classifying, quantifying, and analyzing the benefits and costs of research investments. Third, it presents a generic format for summarizing the economic impacts of research investments. Fourth, it illustrates - by way of two case studies - how the framework, evaluation methods, and generic format would be applied in practice. The first case study provides estimates of the economic impacts from past BFRL research leading to the introduction of the ASHRAE 90-75 standard for residential energy conservation. The energy costs of the ASHRAE 90-75 standard are compared to those of pre-1973 oil embargo standards. More than $900 million (in 1975 dollars) of the energy savings from ASHRAE 90-75 modifications in single-family houses were directly attributable to the BFRL activities that promoted the development of ASHRAE 90-75. The second case study provides estimates of the net dollar savings from a past BFRL research effort leading to the development of an improved asphalt shingle for sloped roofing. BFRL's contribution resulted in a faster adoption of the longer-lasting 235 shingle, which significantly reduced roofing costs to building owners.

Chapman, R. E.; Weber, S. F.
Benefits and Costs of Research: A Case Study of the Fire Safety Evaluation System.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5863; 85 p. July 1996.

Available from National Technical Information Service
PB96-202288

benefit cost analysis; building economics; construction; economic analysis; fire safety; impact evaluation; life cycle costing; performance standards; research impacts

The National Institute of Standards and Technology (NIST) is improving its resource allocation process by doing "microstudies" of its research impacts on society. This report is one of a series of microstudies prepared by NIST's Building and Fire Research Laboratory (BFRL). This report focuses on a critical analysis of the economic impacts from past BFRL research efforts leading to the development and introduction of the performance-based Fire Safety Evaluation System (FSES) for health care facilities. The FSES was developed as an alternative to prescriptive compliance to the Life Safety Code for hospitals and nursing homes participating in the Medicare and Medicaid programs. This study of the FSES illustrates how to apply in practice a series of standardized methods to evaluate and compare the economic impacts of alternative research investments. The study is presented in sufficient detail to understand the basis for the economic impact analysis and to reproduce the results. It is an ex post study in that it is based on past research efforts. The results of this study demonstrate that the FSES has generated substantial cost savings to hospitals and nursing homes across the nation. The present value of savings nationwide attributable to the FSES is nearly $1 billion ($987 million in 1995 dollars). Furthermore, because of BFRL's timely involvement and leadership, the FSES was adopted into the Life Safety Code in 1981. The first fully-documented use of the FSES was in 1983. If BFRL had not participated in the development of the FSES, adoption into the Life Safety Code would likely have taken place in 1988. Consequently, potential cost savings accruing to hospitals and nursing homes over the period 1983 through 1989 would have been foregone. These cost savings are $564 million in 1995 dollars. These cost savings measure the value of BFRL's contribution for its research investment of approximately $4.5 million.

Cheok, G. S.; Stone, W. C.; Nakaki, S. D.
Simplified Design Procedure for Hybrid Precast Concrete Connections.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5765; 92 p. February 1996.
Available from National Technical Information Service
PB96-154836

building technology; beam-column; concretes; connection; joint; drift capacity; moment capacity; precast; post-tensioning; seismic design procedure

A rational design procedure is presented to compute the probable moment, the nominal moment, and the story drift capacities of a hybrid precast moment-resisting beam-to-column connection. The hybrid connections consist of mild steel which is used to dissipate energy by yielding and high strength prestressing steel which is used to provide the shear resistance through friction developed at the beam-column interface by the post-tensioning force. The design procedure is based on three 1/3-scale hydrid 20 precast beam-to-column connections tested at the National Institute of Standards and Technology (NIST). The simplified procedure relies on the stress-strain behavior of mild steel up to its ultimate strength and is based on equilibrium equations at the beam-column joint. The appendices include a commentary of the design procedure, proposed evaluation criterion for this hybrid connection, sample calculations using the design procedure, and other calculations used to develop the design criterion.

Chien, W.; Yang, J. C.; King, M. D.; Grosshandler, W. L.
Evaporation of a Small Aqueous Suppressing Agent Droplet.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 5-6 pp, 1996.
Available from National Technical Information Service

fire research; fire science; droplets; halon alternatives; evaporation

Due to its ozone-depleting potential, halon 1301 (CF3Br) has been banned from production under the Montreal Protocol. The research for halon replacement(s) has led to the reconsideration of using water in certain applications. However, under cold storage conditions (below 0DGC) water will freeze, thus posing a limitation in low temperature operations. Certain additives, if selected properly, not only can suppress the freezing point of water but also can improve its fire suppression effectiveness. Some water-based agents have recently been proven to be more effective than pure water when used in the form of mist to suppress a small JP-8 pool fire. Among the thirteen agents they tested, potassium lactate (60% w/w) and potassium acetate (60% w/w) were found to be far superior than pure water and other candidate solutions.

Chin, J. W.
Materials Aspects of Fiber-Reinforced Polymer Composites in Infrastructure.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5888; 46 p. August 1996.
Available from National Technical Information Service
PB96-210695

polymer composites; construction; civil engineering; infrastructure; fibers; durability; rehabilitation; retrofitting

This paper provides a review of the technical literature pertaining to materials aspects of fiber-reinforced polymer (FRP) composites in infrastructural and other civil engineering applications. The main focus is placed upon the durability, chemical and mechanical aspects of structures reinforced with or constructed from FRP materials. Categories which are addressed include marine applications, structural shapes, joining/fastening, reinforced concrete and rehabilitation/retrofitting of structures. Effects of moisture, salt water, alkalinity and mechanical loading on the performance of FRP components are emphasized.

Choi, D. K.; Domanski, P. A.; Didion, D. A.
Evaluation of Flammable Refrigerants for Use in a Water-to-Water Residential Heat Pump.
Samsung Electronics, Kyungki-Do, Korea
National Institute of Standards and Technology, Gaithersburg, MD
International Institute of Refrigeration. Applications for Natural Refrigerants. September 1996, Aarhus, Denmark, 1-10 pp, 1996.

refrigerants; heat pumps; water; evaluation; cooling; heating; test facilities

This paper evaluates the performance of R-22, R-290, R-290/600a (70/30), and R-32/152a (50/50) for application in a water-to-water residential heat pump for space cooling and heating. The tests were performed in a laboratory apparatus at different compressor speeds to allow the comparison of refirgerants for the constant-compressor-speed and the constant-capacity criteria. Comparison of results for the same system capacity showed R-32/152a to be the best performer due to good glide matching in the heat exchangers and its excellent thermodynamic and transport properties. The hydrocarbon mixture, R-290/600a, had the highest Coefficient of Performance (COP) at a given compressor speed, but its COP at the constant-capacity criterion was the lowest. This low COP was in disagreement with an earlier simulation study where R-290/600a and R-32/152a had a similar COP. The test data showed that the low-volumetric-capacity R-290/600a had an excessive pressure drop at the constant-capacity comparison. This was related to the high compressor RPM needed for R-290/600a to reach the target capacity. With an optimized compressor and heat exchangers using larger diameter tubes, R-290/600a should have a COP comparable to that of R-32/152a. The study demonstrates the need for both simulations and laboratory methods in evaluating alternative refrigerants.

Chung, R. M.; Ballantyne, D.; Comeau, E.; Holzer, T.; Madrzykowski, D.; Schiff, A.; Stone, W. C.; Wilcoski, J.; Borcherdt, R.; Cooper, J.; Lew, H. S.; Moehle, J.; Sheng, L. H.; Taylor, A. W.; Bucker, I.; Hayes, J.; Leyendecker, E. V.; O'Rourke, T.; Singh, M. P.; Whitney, M.

January 17, 1995 Hyogoken-Nanbu (Kobe) Earthquake: Performance of Structures, Lifelines, and Fire Protection Systems.

National Institute of Standards and Technology, Gaithersburg, MD
Department of Transportation, CA
Federal Aviation Administration, Atlantic City International Airport, NJ
National Center for Earthquake Engineering Research
National Fire Protection Association, Quincy, MA
National Science Foundation, Washington, DC
Army Construction Engineering Research Laboratory, Champaign, IL
Geological Survey

NIST SP 901; ISCCS TR18; 573 p. July 1996.

Available from National Technical Information Service
PB97-104160

earthquakes; airports; bridges (structures); building fires; building technology; engineering seismology; electric power; gas; geology; geotechnology; lateral spread; lifelines; liquefaction; reinforced concretes; sewage; steels; telecommunications; wastewater; water; wood frame construction; transportation

The January 17, 1995 Hyogoken-Nanbuearthquake of magnitude 7.2 in JMA scale (Mw = 6.9), which struck Kobe, Japan and its surrounding area was the most severe earthquake to affect that region this century. The earthquake resulted in more than 6,000 deaths and over 30,000 injuries. Fires following the earthquake incinerated the equivalent of 70 U.S. city blocks. They together destroyed over 150,000 buildings and left about 300,000 people homeless. The economic loss as a result of this earthquake is estimated to reach $200 billion. An investigation was conducted under the auspices of the Panel on Wind and Seismic Effects of the U.S.-Japan Program in Natural Resources to observe, document, and summarize important lessons from this earthquake that can be used to mitigate the potentially tragic impact of future earthquakes on modern urbanized communities. An 18-member team was in Japan from February 12 to February 18, 1995 to study seismology, geology, and geotechnical effects; as well as the performance of buildings, lifelines, and fire safety systems. This document summarizes the information collected during as well as following this investigation. Key findings of the investigation include needs for research and for improvements in practices to achieve earthquake loss reduction in the United States.

Cleary, T. G.; Grosshandler, W. L.; Nyden, M. R.; Rinkinen, W. J.

Signatures of Smoldering/Pyrolyzing Fires for Multi-Element Detector Evaluation.

National Institute of Standards and Technology, Gaithersburg, MD

Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 497-506 pp, 1996.

fire safety; fire suppression; fire detection; fire signatures; smoldering; test fires

Levels of CO, CO2, H2O, hydrocarbons, smoke, temperature and velocity produced in the plumes of smoldering/pyrolyzing wood and smoldering cotton fires are reported, following test protocols described for evaluating automatic fire detection systems. The repeatability of the wood fires is high, but the smoldering cotton results can vary considerably depending upon the exact configuration of the fuel. The water vapor builds up most quickly in both fires, with CO and CO2 growing more

slowly in volume fraction but at a close to constant ratio. Temperatures increase steadily on the plume centerline, and the vertical velocities correlate rougly with the square root of the difference in plume and surrounding temperatures. The data are compared to previous results, and a method for using these measurements to evaluate multi-criteria fire detection systems is proposed.

Cooper, L. Y.
Calculating Combined Buoyancy- and Pressure-Driven Flow Through a Shallow, Horizontal, Circular Vent: Application to a Problem of Steady Burning in a Ceiling-Vented Enclosure.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Journal, Vol. 27, 23-35, 1996.

fire research; vents; buoyancy; pressure; ceilings; enclosures; algorithms; equations; energy release rate; ships; wood; ceiling vents

A model was developed previously for calculating combined buoyancy- and pressure-driven (i.e., forced) flow through a shallow, circular, horizontal vent where the vent-connected spaces are filled with fluids of different density in an unstable configuration (density of the top fluid is larger than that of the bottom). In this paper, the model is summarized and then applied to the problem of steady burning in a ceiling-vented enclosure where normal atmospheric conditions characterize the upper-space environment. Such fire scenarios are seen to involve a zero to relatively moderate cross-vent pressure difference and bidirectional exchange flow between the enclosure and the upper space. A solution to the problem leads to a general result that relates the rate of energy release of the fire to the area of the vent and the temperature and oxygen concentration of the upper portion of the enclosure environment. This result is seen to be consistent with previously published data from experiments involving ceiling-vented fire scenarios.

Cooper, L. Y.; Steckler, K. D.
Methodology for Developing and Implementing Alternative Temperature-Time Curves for Testing the Fire Resistance of Barriers for Nuclear Power Plant Applications.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5842; 116 p. May 1996.
Available from National Technical Information Service
PB96-193784

nuclear power plants; ASTM E119; cables; fire barriers; fire endurance; fire models; fire resistance; histories; temperature; zone models

Advances in fire science over the past 40 years have offered the potential for developing technically-sound alternative temperature-time curves for use in evaluating fire barriers for areas where fire exposures can be expected to be significantly different than the ASTM E119, standard, temperature-time exposure. The U.S. Nuclear Regulatory Commission (NRC) staff initiated the current effort to investigate the feasibility of developing alternative temperature-time curves for the qualification of fire barriers used to protect cabling and equipment necessary to achieve safe shutdown on the basis of realistic fire hazards found in nuclear power plants (NPPs). The approach taken in the current study consists of three steps or tasks: 1) review the history of the ASTM E119 temperature-time curve to assess its current applicability and limitations in simulating real fires; 2) review the history of efforts to develop alternative curves and the methodologies used; and 3) use the findings from (1) and (2), knowledge of NPP construction, fuel types and loads, and state-of-the-art fire science to propose a methodology for developing and implementing NPP-specific descriptions of fire environments and associated ASTM-type temperature-time curves and test methods. Results of each task are reported. The proposed methodology calls for a combination of zone modeling and large-scale fire experiments.

D

Dai, Z.; Krishnan, S. K.; Sangras, R.; Wu, J. S.; Faeth, G. M.
Mixing and Radiation Properties of Buoyant Luminous Flame Environments.
Michigan Univ., Ann Arbor
NIST-GCR-96-691; GDL/GMF-95-02; 90 p. June 1996.
Available from National Technical Information Service
PB96-202254

diffusion flames; fire research; optical properties; soot; turbulent flames

An investigation of the radiation and mixing properties of buoyant turbulent diffusion flames is described. The study was divided into two phases: (1) the optical and radiative properties of soot, which must be understood in order to develop non-intrusive methods for measuring soot properties and to estimate the continuum radiation properties of soot in flame environments, and (2) the structure and mixing properties of buoyant turbulent plumes, which must be understood in order to resolve effects of turbulence/radiation interactions and to benchmark computationally tractable models of buoyant turbulent flows. Consideration of the optical and radiative properties of soot involved evaluation of the Rayleigh-Debye-Gans (RDG) scattering approximation for soot aggregates and the use of this theory to measure the refractive indexes in the visible region (350-800 nm). In addition, dimensionless extinction coefficients and the soot fractal dimensions were measured. The structure and mixing properties of buoyant turbulent plumes were investigated by examination of the effects of coflow on earlier measurements and by evaluating various modeling approximations, with an emphasis on self-preserving round buoyant turbulent plumes.

Davis, W. D.; Notarianni, K. A.
NASA Fire Detector Study.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5798; 38 p. March 1996.
Available from National Technical Information Service
PB96-183108

fire detection systems; fire simulation; fluid flow; heat detection; radiation detection; smoke detection; ventilation; clean room fire; detection time

The National Aeronautics and Space Administration, together with the National Institute of Standards and Technology are in the third year of a five year project designed to set guidelines for fire protection in high bay facilities. A high bay facility is defined in this study as any space with a ceiling height in excess of 18 m. NASA has numerous high bay spaces that are used to perform a variety of functions. A survey of NASA high bay spaces was conducted to determine the number of spaces, the use of the space, fire detection and suppression present, geometry and presence of forced air flow or clean room conditions, and special hazards which would pose substantial fire risks. Based on the survey results, a modeling program was designed which would analyze both specific and generic high bay spaces representative of the NASA inventory. The computation fluid dynamics model HARWELL-FLOW3D was used for the modeling. The object of the modeling was to simulate the response of smoke, fusible link, heat, UV/IR, and obscuration detectors to several standard fire scenarios. The modeling was done for both forced air flow and no air flow present in the space. Results of the predicted detector activation times are presented as a function of fire size, ceiling height, and forced air flow.

Davis, W. D.; Notarianni, K. A.; McGrattan, K. B.
Comparison of Fire Model Predictions With Experiments Conducted in a Hangar With a 15 Meter Ceiling.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5927; 61 p. December 1996.
Available from National Technical Information Service
PB97-129555

aircraft hangars; fire models; experiments; simulation; fire tests; heat detection; smoke detection; computational fluid dynamics; zone models

The National Aeronautics and Space Administration together with the National Institute of Standards and Technology are in the fourth year of a five year project designed to help NASA set guidelines for fire protection in high bay facilities. A high bay facility is defined in this study as any space with a ceiling height in excess of 9 m. NASA has numerous high bay spaces that are used to perform a variety of functions. The work this year made use of a set of fire experiments conducted in a 15 m high hangar by NIST and the U.S. Navy to study the predictive capabilities of zone fire models and computational fluid dynamics models (CFD). The models studied included the zone models CFAST, DETACT-QS, FPETool, and LAVENT and the CFD models CFX and NIST-LES. The study compares the model predictions with measured temperature profiles in the ceiling jet and the plume. Velocity measurements, smoke detector activation and the impact of draft curtains on smoke flow are also analyzed. The fires sizes studied in the experiment are 500 kW and 2.7 kW JP-5 pan fires.

Davis, W. D.; Notarianni, K. A.; McGrattan, K. B.
Comparison of Fire Model Predictions With Experiments Conducted in a Hangar With a Ceiling Height of 14.9 m.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 75-76 pp, 1996.
Available from National Technical Information Service

fire research; fire science; aircraft hangars; ceiling height; fire models; experiments

The purpose of this study is to examine the predictive capabilities of fire models using the results of two fire experiments conducted in an aircraft hangar with a ceiling height of 14.9 m (49 ft.). The fire experiments were conducted at Barbers Point, Hawaii by NIST in conjunction with the United States Navy. This study is designed to investigate fire model applicability at a ceiling height where only a limited amount of experimental data is available. Some earlier efforts to compare computer fire models with experimental data at heights above 14 m include Walton, Duong and Notarianni and Davis. Model predictions compared with the experiments include: plume centerline temperature at the ceiling, temperature, ceiling jet velocity, draft curtain filling and spilling times, temperature variation across the draft curtain and smoke detector activation. The fire models included in the study are the plume correlations of Heskestad and McCaffrey, the ceiling jet correlation of Alpert, the zone models CFAST, FPETool, and LAVENT, and the computational fluid dynamics models (CFD) CFX and LES.

Dawson, H. F.; diMarzo, M.
Multi-Droplet Evaporative Cooling: Experimental Results.
Maryland Univ., College Park
NIST-GCR-96-687; Paper 12; June 1996.
Available from National Technical Information Service
PB96-202304

water sprays; evaporation cooling; solid surfaces; temperature distribution; surface temperature; data processing; thermal conductivity; droplets

Experimental results concerning the evaporative cooling of a Macor tile subjected to a random droplet distribution are reported. The heat input is provided by three radiant panels above the solid surface. The spatial transient temperature distribution over the solid surface and its average surface temperature history are described.

Delichatsios, M. A.; Karydas, D. M.
Framework for Fire Risk Assessment of Buildings Based on Performance Based Engineering Analysis.
Factory Mutual Research Corp., Norwood, MA
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 153-154 pp, 1996.
Available from National Technical Information Service

fire research; fire science; fire risk; risk assessment; computer models; risk analysis

Fire research and fire safety science have made so much progress over the last twenty years that engineers, designers and regulators are using or willing to use computer mathematical models to specify fire safety equipment and assess the fire hazard of an occupancy instead of using only prescriptive building or equipment (approval) codes. To make these computer codes credible and easily available to engineers and regulators, there is need to ease the application of the computer codes by proper interfaces and also at the same time provide the user with a methodology to evaluate the validity of outputs by performing for example what-if-analysis.

Dikkers, R. D.; Chung, R. M.; Mohraz, B.; Lew, H. S.; Wright, R. N., Editors
Proceedings of a Workshop on Developing and Adopting Seismic Design and Construction Standards for Lifelines.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5907; 345 p. October 1996.
Available from National Technical Information Service
PB97-115794

lifelines; seismic design; construction; standards; electrical power; telecommunications; transportation; water

The recommendations for developing and adopting seismic design and construction standards for lifelines presented in this report were prepared in response to Public Law 101-614, the National Earthquake Hazard Reduction Program (NEHRP) Reauthorization Act. The recommendations were based on inputs from experts in research and practice of lifeline earthquake engineering in private and public sectors; the Technical Council on Lifeline Earthquake Engineering of the American Society of Civil Engineers; utility organizations; and local, state, and federal government who participated in a workshop in Denver, Colorado, September 25-27, 1991. The workshop concluded that standards are needed to reduce the vulnerability of lifelines to earthquakes, and recommended the need to develop recommendations for standards, encourage and support the adoption of these recommendations by the standard organizations serving the lifeline community, and to work with the lifeline community to achieve their implementation. Parts of these recommendations were included in the "Plan for Developing and Adopting Seismic Design Guidelines and Standards for Lifelines," FEMA 271, 5/96, submitted by the Federal Emergency Management Agency to Congress in September 1995.

diMarzo, M.
Sparse Water Sprays in Fire Protection.
Maryland Univ., College Park
NIST-GCR-96-687; 252 p. June 1996.
Available from National Technical Information Service

PB96-202304

water sprays; fire protection; drop size measurements; evaporation cooling; fire research; fire suppression; solid surfaces; thermal conductivity

A comprehensive review of the findings that punctuated ten years of research on dropwise evaporative cooling is presented. The first studies consider a single droplet evaporating on a high thermal conductivity solid surface. The solid-liquid coupling is addressed when considering the case of a low thermal conductivity solid. A powerful, non-intrusive, infrared thermographic technique is instrumental in describing the thermal behavior of the solid surface. The applications relevant to fire suppression suggest the imput of radiant heat from above the surface instead of heat conducted through the solid. Once the single droplet behavior is fully documented experimentally and accurately modeled, the study of sparse water sprays is undertaken. A superposition model is formulated which well represents the experimental data.

diMarzo, M.; Tartarini, P.; Liao, Y.; Evans, D. D.; Baum, H. R.
Evaporative Cooling Due to a Gently Deposited Droplet.
Maryland Univ., College Park
National Institute of Standards and Technology, Gaithersburg, MD
NIST-GCR-96-687; Paper 7; June 1996.
Available from National Technical Information Service
PB96-202304

water sprays; evaporation cooling; droplets; equations; formulations; surface temperature; temperature distribution; evacuation time

The transient thermal behavior of a single water droplet gently deposited on the surface of a semi-infinite solid is investigated. A coupled model that solves simultaneously the transient condition equation for the solid and the liquid to yield the surface temperature and heat flux distributions as well as the description of the droplet evaporation transient is proposed. The predictions of the evaporation time are compared with experimental data. An additional model is presented which assumes constant heat flux at the liquid-solid interface. This model provides a closed form solution for the solid surface transient temperature distribution.

diMarzo, M.; Tinker, S.
Evaporative Cooling Due to a Sparse Spray.
Maryland Univ., College Park
NIST-GCR-96-687; Paper 14; June 1996.
Available from National Technical Information Service
PB96-202304

water sprays; evaporation cooling; sprays; droplets; solids; surface temperature; experiments; equations

The cooling effect of a sparse spray impinging on a semi-infinity solid is investigated. Experiments are conducted by monitoring, via infrared thermography, the surface of the solid heated by radiation and cooled by sprays of uniform size droplets until steady state conditions are reached. The surface temperature field in the proximity of a single droplet is modeled with a closed-form solution based on the hypothesis of constant and uniform heat flux at the solid-liquid interface. In the far-field, an instantaneous point-sink solution is adequate to represent a single droplet cooling effect. These closed-form solutions are used to fit the results of a coupled model, previously developed, which solves the liquid and solid temperature field for the evaporative transient. Inputs from this model are necessary for the formulation of both the closed-form solutions. The spray model formulation is based on the superposition of the cooling effect of all the droplets deposited on the surface. The transient surface temperature distributions and the average surface temperature are compared for the data and computations. The results are in good agreement for similar random droplet distributions of the order of one g/m2s with initial solid surface temperatures ranging between 130 and 160 DGC.

Dols, W. S.; Persily, A. K.; Nabinger, S. J.
Indoor Air Quality in Green Buildings: A Review and a Case Study.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc., Atlanta, GA
Paths to Better Building Environments/Environmental Effects on Health and Producitivity. IAQ '96 Conference. Proceedings. American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE). October 6-8, 1996, Baltimore, MD, ASHRAE, Atlanta, GA, Teichman, K. Y., Editor, 139-150 pp, 1996.

building performance; green building; indoor air quality; office buildings; ventilation

The term "green building" is used to describe buildings that are designed, constructed, and operated, to have a minimum impact on the environment, both indoor and outdoor. Most discussions of green buildings refer to the importance of providing an acceptable, if not exceptional, indoor environment for the building occupants. However, these discussions of indoor environment quality have not included many specific recommendations or criteria for building design, construction, or operation. Building projects described as green building demonstrations often make reference to indoor air quality, but these references are often general and qualitative. In addition, rating systems that have been developed to assess the "greeness" of a building are based largely on design features and are not particularly specific with respect to indoor air quality. This paper reviews the features of indoor air quality that are considered in green building discussions, demonstration projects, and rating systems. These green building features are discussed in terms of their completeness and specificity, and are compared to other guidance on building design, construction, and operation for good indoor air quality. A case study of indoor air quality performance in a green building is presented. This study includes a description of the indoor air quality features of the building and the results of a short-term indoor air quality evaluation of the building involving ventilation and contaminant concentration measurements.

Domanski, P. A.
Minimizing Throttline Losses in the Refrigeration Cycle.
National Institute of Standards and Technology, Gaithersburg, MD
International Congress of Refrigeration, 19th Proceedings. Volume IVb. Theme 4. IIR Commission B2. August 1995, Hague, The Netherlands, 766-773 pp, 1995.

refrigeration; air conditioning; economizer; ejector; liquid-line/suction-line heat exchanger; Rankine cycle; vapor compression cycle

Most alternative non-CFC refrigerants have a large molecular structure and large heat capacity, which influence the slope of saturated liquid line and result in substantial throttling losses in a basic reversed Rankine cycle. These losses degrade the cycle efficiency below that of the original CFC fluids; virtually all carbon-based non-hydrocarbon refrigerants have a lower Coefficient of Performance than the fluids banned by the Montreal Protocol. This study analyzes the performance of pure-component refrigerants in the basic refrigeration (reversed Rankine) cycle and in three modified cycles in which the throttling-process irreversibilities are minimized: the liquid-line/suction-line heat exchange (llsl-hx) cycle, the economizer cycle, and the ejector cycle. The refrigerants considered in this study were the 38 fluids covered by REFPROP /1/, and REFROP property routines were employed in performance simulations. The Carnahan-Starling-DeSantisequation of state was applied for all fluids except ammonia, for which a formulation by Harr and Gallagher was used.

Duthinh, D.; Carino, N. J.
Shear Design of High-Strength Concrete Beams: A Review of the State-of-the-Art.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5870; 203 p. August 1996.
Available from National Technical Information Service
PB96-214713

building technology; compression field theory; design codes; high strength concrete; reinforced concretes; shear strength; strut and tie model; truss model

This state-of-the-art review of the shear design of high-strength concrete (HSC) beams consists of four parts. In the first part, various analysis methods are presented: a) The plastic solution assumes that both concrete, modeled as a modified Mohr-Coulomb material and steel reinforcement are at yield. Under shear loading, the concrete web develops an inclined compression field which satisfies both upper and lower bound theorems. A plastic solution of shear friction is also discussed. b) Both the compression field theory and the modified compression field theory (MCFT) are "exact" theories in the sense that they satisfy equilibrium, compatibility of displacements and stress-strain relationships. The MCFT accounts for the contribution of the tensile strength of concrete to shear resistance. c) Other "exact" solutions are also discussed, that do not assume that the principal stress and principal strain directions are aligned with each other, as the MCFT does. d) the 45DG truss, the variable angle truss (VAT) and strut-and-tie models (STM) belong to a class of solutions that only satisfy equilibrium. The second part of the report is a comparison of various National Codes: a) The ACI Code is semi-empirical and based on the 45DG truss with a correction term called the concrete contribution. For shear-friction, the ACI Code only accounts for a friction term. b) The Canadian Code (CSA) and the AASHTO Code are more "rational" and based on the MCFT. STM are acceptable for "D" regions near supports, loads or sudden changes in geometry. For shear-friction, the CSA Code accounts for a friction and a cohesion term. c) The Norwegian (NS) Code's general design method is also based on the MCFT. However, the VAT method and a simplified method are also allowed. Again, STM are acceptable for D regions. For shear-friction, the Norwegian Code accounts for a friction and a cohesion term. d) The Japanese Code is based on an equilibrium theory and considers shear resistance as a combination of arch action and (variable angle) truss action. e) The CEB-FIP Code is based on the VAT, and f) so is the French Prestressed Concrete Code which includes a concrete contribution term. g) However, the French Reinforced Concrete Code is based on the 45DG truss with a concrete contribution term. The third part of the report is a review of research results: a) Beam test results are surveyed and compared to various empirical and design code equations. b) Panel tests are reviewed, that simulate the state of biaxial tension and compression in beam webs. c) Shear friction measurements and theories are discussed and d) Size effect is briefly covered, with the help of fraction mechanics. The last part of the report discusses future work. We recommend that emphasis be placed on experimental measurement of the shear friction properties of HSC. Biaxial behavior is also important, but would require a major commitment in funding. In addition, we recommend that NIST perform a parametric study of the strength of HSC beans, using the MCFT, to determine the influence of various models of shear friction and biaxial tension-compression softening; and that the work on automation of strut-and-tie modeling be expanded.

E

Ehlen, M. A.; Marshall, H. E.
Economics of New-Technology Materials: A Case Study of FRP Bridge Decking.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5864; 73 p. July 1996.
Available from National Technical Information Service
PB96-202353

breakeven analysis; building economics; construction materials; cost classification; cost effective; cost estimation; economic methods; elemental classification; engineering economics; engineering design; FRP composites; high performance materials; infrastructure investment; life cycle cost analysis; R&D expense; sensitivity analysis; spillover costs; user costs; value engineering

Many new materials are being developed from polymers, metals, and ceramics. Industry is beginning to introduce some of these high-performance or new-technology materials in construction and manufacturing applications because the materials have advantages over traditional materials like steel, concrete, wood, and aluminum. However, many high-performance materials have not been used in large-scale construction projects. Economic and Technical Barriers hinder industry's aggressive introduction of these new technologies despite their advantages over traditional materials. The primary economic barrier

preventing the use of new technology material is their high initial cost. Regardless of how cost effective a material might be over the life cycle of the project, industry balks at high up-front costs, particularly when the life-cycle costs of a new material are relatively uncertain. This cost barrier inhibits construction applications of - and eventually research in - new materials. Yet the construction industry has many potential applications; for example, fiber-reinforced polymers (FRPs) and high-performance concrete and steel are technically viable substitutes for conventional bridge materials. FRPs are also likely candidates for use in marine structures and offshore oil rigs. Germany and Japan are leading the world in FRP use in construction; if U.S. companies are to remain globally competitive, they too will likely need to introduce new technology materials in their construction projects. To overcome this cost-based barrier to the adoption of new materials, the construction industry needs practical economic methods for evaluating alternative building and construction materials in a comprehensive and consistent manner. Providing a guideline for determining life-cycle cost effectiveness will give decision makers a tool to help them select, both for research and construction applications, those materials that will make firms competitive and help government agencies deliver the nation's infrastructure at minimum life-cycle cost. This report provides such a method for evaluating the life-cycle cost effectiveness of new-technology materials in relation to conventional materials. The method provides users with a tool that helps them choose that material among competing alternative materials that perform the required function at minimum life-cycle cost. This method can be used to satisfy the Intermodel Surface Transport Efficiency Act's requirement that life-cycle costs be considered in the design of transportation-related structures, and Executive Order 12893 which requires that the costs of federal infrastructure investment be accounted for over the life span of each project. The method is consistent with ASTM Standards for computing life-cycle costs. A three-level, hierarchical cost classification presents the types of costs that characterize the use of conventional and new-technology materials; this helps analysts identify all of the costs - including spillover costs to project users and others - that are appropriate for an economic analysis. An economic case study of bridge decks evaluates the use of three FRP materials as alternatives to conventional concrete. A sensitivity analysis shows how significant various cost items are toward making FRP composite decks economically competitive. Suggestions for further research in the economics of new-technology materials completes the report. The methods presented are equally applicable to non-construction materials and projects, as well as the evaluation of any capital budget expenditure as long as the performance of each competing alternative meets project requirements.

Emmerich, S. J.; Persily, A. K.
Multizone Modeling of Three Residential Indoor Air Quality Control Options.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5801; 142 p. March 1996.
Available from National Technical Information Service
PB96-165782

air flow; building technology; computer simulation; filtration; heat recovery ventilation; heating; ventilation; air conditioning; indoor air quality; infiltration; residential buildings; quality control

[*]Superceeds NISTIR 5346; NISTIR 5559; NISTIR 5712[*] The National Institute of Standards and Technology (NIST) performed a preliminary study of the use of central forced-air heating and cooling system modifications to control indoor air quality (IAQ) in residential buildings. The objective of this effort was to provide insight into the use of state-of-the-art multizone airflow and IAQ models to evaluate such modifications, the potential of these modifications to mitigate residential IAQ problems, the pollutant sources they are most likely to impact, and their potential limitations. This study was not intended to determine definitively whether the IAQ control options studied are reliable and cost-effective. Another important objective of the project was to identify issues related to the use of multizone IAQ models and to identify areas for follow-up work. This report summarizes the three phases of this effort, each of which consisted of three main tasks. The Phase I tasks included conducting a literature review, developing a plan for computer analysis, and holding a workshop to discuss the plan. The Phase II.A tasks included baseline simulations of contaminant levels without indoor air quality (IAQ) controls, design of the IAQ control retrofits, and preliminary simulations of contaminant levels with the IAQ control retrofits. The Phase II.B tasks included computer simulations of contaminant levels with IAQ control retrofits, evaluation of the effectiveness of the IAQ control retrofits, and development of recommendations for future research. This report is a consolidation of the three previous reports on the project: Emmerich and Persily 1994 on Phase I, Emmerich and Persily 1995a on Phase II.A, and Emmerich and Persily 1995b on Phase II.B. The multizone airflow and pollutant transport program CONTAM93 was used to simulate the pollutant concentrations due to a variety of sources in eight buildings with typical HVAC systems under different weather conditions. Three indoor air quality control technologies were incorporated into the house models to determine their

effectiveness in controlling the modeled pollutant sources. The technologies include the following: electrostatic particulate filtration, heat recovery ventilation, and an outdoor air intake damper on the forced-air system return. Simulation results indicate that the system modifications reduced pollutant concentrations in the houses for some cases. However, the heat recovery ventilator and outdoor air intake damper increased pollutant concentrations in certain situations involving a combination of weak indoor sources, high outdoor concentrations, and indoor pollutant removal mechanisms. In cases where the IQA controls reduced pollutant concentrations, they led to larger relative reductions in the tight houses than in the house with typical levels of airtightness, though the typical houses still had lower post-control concentrations. The controls had the largest impact on concentrations of non-decaying pollutant from a constant source. Limited system run-time under mild weather was identified as a limitation of IAQ controls that operate in conjunction with forced-air systems.

Evans, D. D.
Large Fire Experiments for Fire Model Evaluation.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 329-334 pp, 1996.

fire safety; large scale fire tests; fire research; fire tests; hydrocarbon fuels; oil spills; smoke yield; field tests

Recent movement towards performance based evaluation of building safety has placed a premium on demonstrating the accuracy of engineering methods and increased the demand for fire performance data from large scale experiments. Data from large scale experiments are generally the basis for development and evaluation of fire models. Verification of engineering methods for prediction of fire related performance of structures, contents, and fire protection systems has become a priority need to support the development of performance based codes and standards. Generally a great impediment to model verification is the lack of means to quantify the degree of agreement between experiments and predictions or repeated experiments. Today, the most widely used fire models are based on two-zone predictive methods for fire flow in buildings. These methods along with implementation of engineering correlations developed from large scale fire experiments which include those for prediction of the performance of fire protection systems form the basis of modern fire safety engineering practice. The widespread availability of fast computing power, particularly in the fire research community, has made it possible to model fires in buildings using high resolution field modeling techniques. These are available commercially from engineering software developers and as research tools developed in many of the fire safety laboratories around the world. As an example, NIST has experimented with the capabilities of Large Eddy Simulation technology to predict fire driven flows inside and outside of structures. The results have shown that modeling of building fire flows at a resolution of several centimeters is feasible. The advent of high resolution calculations for use in fire safety analysis has increased the demand for high resolution measurements of fire conditions in buildings. To meet the demands of the user community, large scale fire testing is increasing in scale, in the number of quantities measured, and in temporal and spacial resolution of the measurements. In addition, means are being developed to readily exchange data among users and research facilities.

Ezekoye, O. A.; Zhang, Z.
Residence Time Effects on Soot Growth Processes.
University of Texas, Austin
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 23-24 pp, 1996.
Available from National Technical Information Service

fire research; fire science; soot; time

Soot growth processes affect both the radiative heat transfer distribution in a fire as well as the smoke properties. While it is difficult to achieve long residence time effects in laboratory scale flames at normal gravity, it is relatively easier to produce these conditions in microgravity flames. Within a novel microgravity burner configuration used by Atreya and coworkers 2 and 3 seconds of residence time are achieved in a relatively small microgravity flame. We have performed computational and theoretical investigations of the soot growth processes within this geometry as well as investigations of the convective and radiative coupling on the total radiative transfer and burner characteristics.

F

Fahy, R. F.
Enhancement of EXIT89 and Analysis of World Trade Center Data.
Final Report. August 1994-August 1995.
National Fire Protection Association, Quincy, MA
NIST-GCR-95-684; 45 p. June 1996.
Available from National Technical Information Service
PB96-202247

computer simulation; egress; field tests; fire models; human behavior; training

The features of an enhanced model for egress from fires in non-residential occupancies is presented along with a users manual describing the use of the model. The enhancements to the model include analysis of locations of safety, smoke blockages, disabled occupants, and delays in egress. Comparisons with some available field measurements is presented. Further analysis of human behavior during a fire in the World Trade Center is presented. The analysis shows that there was a signficiant difference in perception of the severity of the fire between the two buildings of the World Trade Center. While previous human behavior studies have shown that people will move through smoke, this incident demonstrated that people will not only move through smoke, but also through worsening conditions. Implications for evacuation and training are discussed.

Fahy, R. F.
EXIT89: High-Rise Evacuation Model - Recent Enhancements and Example Applications.
National Fire Protection Association, Quincy, MA
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 1001-1005 pp, 1996.

fire safety; high rise buildings; evacuation; people movement; fire models; smoke movement; evacuation time; handicapped

EXIT89 was designed to model the evacuation of a large building while tracking the travel paths of each individual occupant. In combination with a fire and smoke movement model, EXIT89 can be used to predict the effects of fire spread on evacuation. Used alone, it can provide a best-case evacuation time estimate. The model has been enhanced to allow the user to specify occupants' travel paths, to delay the beginning of evacuation by location or randomly among all occupants and to simulate the presence of disabled occupants. A beta test version of the model will be distributed by the end of 1995 and plans are to include this model in a future version of HAZARD I. This paper describes recent enhancements in more detail and includes examples that demonstrate the use of those new features.

Fanney, A. H.; Dougherty, B. P.
Photovoltaic Solar Water Heating System.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Solar Energy Engineering, Vol. 118, May 1996.
International Solar Energy Conference. Proceedings. American Society of Mechanical Engineers. March 31-April 3, 1996, San Antonio, TX, 1-10 pp, 1996.

building technology; photovoltaic; solar; water heaters

A novel solar water heating system was patented in 1994. This system used photovolatic cells to generate electrical energy that is subsequently dissipated in multiple electric resistive heating elements. A microprocessor controller continually selects the appropriate heating elements such that the resistive load causes the photovolatic array to operate at or near maximum power. Unlike other residential photovolaticsystems, the photovolaticsolar water heating system does not require an inverter to convert the direct current supplied by the photovolatic array to an alternating current or a battery system for storage. It uses the direct current supplied by the photovolatic array and the inherent storage capabilities of a residential water heater. A photovolaic solar hot water system eliminates the components most often associated with the failures of solar thermal hot water systems. Although currently more expensive than a solar thermal hot water system, the continued decline of photovoltaic cell prices is likely to make this system competitive with solar thermal hot water systems within the next decade. This paper describes the system, discusses the advantages and disadvantages relative to solar thermal water heating systems, reviews the various control strategies which have been considered, and presents experimental results for two full-scale prototype systems.

Fanney, A. H.; Dougherty, B. P.
Thermal Performance of Residential Electric Water Heaters Subjected to Various Off-Peak Schedules.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Solar Energy Engineering, Vol. 118, 73-80, May 1996.

electric heaters; water heaters; tests; computer models; thermal efficiency

A number of electric utilities use residential water heaters for reducing electrical demand. A water heater used in this manner is typically called an off-peak water heater because resistive heating is unrestricted during utility off-peak periods. During on-peak periods, by comparison, the utility seeks to limit and delay resistive water heating. Laboratory tests, where the off-peak period and hot water draw schedule were varied, were conducted on two residential storage water heaters. A computer model of an electric water heater was developed and validated. The laboratory tests and the model were used to quantify the effect that various off-peak and hot water draw schedules have on water heater thermal efficiency. Thermal efficiency was found to vary up to 7% for water heaters which meet the 1991 minimum efficiency standards as specified within the National Appliance Energy Conservation Act. The energy factor, as measured using the Department of Energy Test Procedure for Water Heaters, was found to be independent of the off-peak schedule because of a "normalizing" that occurs as part of the calculation procedure.

Fanney, A. H.; Svincek, P. R.
Third International Green Building Conference and Exposition, 1996.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 908; 225 p. November 1996.
U.S. Green Building Council (USGBC) and the National Institute of Standards and Technology. Green Building Conference and Exposition, 3rd International. Proceedings. November 17-19, 1996, San Diego, CA, Fanney, A. H.; Svincek, P. R., Editors, 1996.
Available from National Technical Information Service
Available from Government Printing Office

building technology; conferences; green buildings; sustainable material; photovoltaics

This report constitutes the proceedings of the Green Building Conference held in San Diego, CA, November 17-19, 1996. The primary objective of the Third Annual Green Building Conference and Trade Show is to provide a forum in which the latest information on sustainable practices, materials, and technologies can be presented. The conference was sponsored by the U.S. Green Building Council, the National Institute of Standards and Technology, the American Society of Landscape Architects and the San Diego Gas and Electric Company. Cosponsors of this event were the American Institute of Architects and the American Society of Interior Designers.

Ferraris, C. F.
Guide to a Format for Data on Chemical Admixtures in a Materials Property Database.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5796; 28 p. April 1996.
Available from National Technical Information Service
PB96-165394

building technology; databases; chemical admixtures; concretes; material properties

The formats for data on chemical admixtures that are described in this report are intended to aid the creation of a coherent system of concrete materials property databases. This preliminary document is a guide that presents a recommended format for use in computerization of concrete materials property data. It addresses the problem of distinguishing one chemical admixture from another by providing a logical scheme for organizing and subdividing material characteristics and parameters to create a unique chemical admixture material identifier. The organization and structure presented in this guide provide a framework for cross-referencing chemical admixture properties, data, and other information which is consistent with the principles laid down in the standard guides that have been prepared by ASTM Committee E-49 and which are due to be adopted by American Concrete Institute (ACI) Committee 126. This preliminary working document is intended to assist the work of ACI committee 126 by providing a draft for use by committee members and others who may wish to offer suggestions for its development. This preliminary document will be superseded by an official ACI document in the series on concrete materials property database formats that is being prepared by ACI 126.

Ferraris, C. F.
Measurement of Rheological Properties of High Performance Concrete: State of the Art Report.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5869; 39 p. July 1996.
Available from National Technical Information Service
PB96-202338

building technology; rheology; cement paste; mortar; concretes; rheology test methods; flow properties; suspension; workability; measurements; prediction; models

The rheology or flow properties of concrete in general and of high performance concrete (HPC) in particular, is important, because many factors such as ease of placement, consolidation, durability, and strength depend on the flow properties. Concrete that is not properly consolidated may have defects like honeycombs, air voids, and aggregate segregation. Such an important performance attribute has triggered the design of numerous test methods. Generally, the flow behavior of concrete approximates that of a Bingham fluid. Therefore, at least two parameters, yield stress and viscosity, are necessary to characterize the flow. Nevertheless, most methods measure only one parameter. Prediction of the flow properties of concrete from its composition or from the properties of its components is not easy. No general model exists, although some attempts have been made. This report gives an overview of the flow properties of a fluid or a suspension, followed by a critical review of the most often used tests for concrete rheology. Particular attention is given to tests that could be used for HPC. Tentative definitions of terms such as workability, consistency and rheological parameters are provided. An overview of the most promising tests and models for cement paste is given.

Ferraris, C. F.; Stutzman, P. E.; Clifton, J. R.
Warping of Terrace Pavers at the U.S. Capitol Building.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5847; 25 p. May 1996.
Available from National Technical Information Service
PB96-193651

building technology; aggregates; alkali-silica reaction; cements; concretes; construction materials; expansion; pavers; warping

The terraces of the U.S. Capitol are covered with cement-based pavers designed to emulate the granite pavers used elsewhere on the Capitol grounds. The pavers were warped after three years of service. These pavers are composed of two layers; an upper, decorative white-cement-based mortar with crushed micaceous quartz aggregate supported by a base of conventional concrete. Field inspection and laboratory testing indicates the warping is probably due to the high cement content, environmental exposure conditions, and possibly differences in hydraulic length changes of two layers comprising the pavers. A cement content of nearly twice that found in typical concretes, leads to higher levels of moisture-driven swelling and shrinkage. This coupled with the different exposure environments of the two materials, i.e., higher relative humidity under the paver and faster drying on the top of the paver, and the differential hydraulic length changes of the two materials used in the pavers leads to warping. Alkali-silica reactivity (ASR) tests indicate that the base layer aggregate is marginally reactive and the upper layer aggregate is non-reactive. While some reaction products were observed in the base layer, expansion due to alkali-silica reaction was not thought to be a significant cause of the warping of the pavers.

Franaszek, M.; Simiu, E.
Application of Chaotic Dynamics to Stochastic Resonance.
National Institute of Standards and Technology, Gaithersburg, MD
Probabilistic Mechanics and Structural Reliability. Proceedings of the Seventh (7th) Specialty Conference. American Society of Civil Engineers. August 7-9, 1996, Worcester, MA, American Society of Civil Engineers, New York, NY, Frangopol, D. M.; Grigoriu, M. D., Editors, 86-89 pp, 1996.

building technology; chaotic dynamics; melnikov processes; signal-to-noise ratio; stochastic resonance; structural engineering

For a class of systems with a periodic signal and noise, the improvement of the signal to noise ratio (SNR) achieved by increasing the noise intensity is referred to as stochastic resonance (SR). We show that, for a class of multistable systems, a chotic dynamics approach to SR allows the assessment of the effect of the spectral density of the noise on the SNR. Using this approach, we also show that, for certain systems, the SNR can be improved more effectively by adding a harmonic excitation than by increasing the noise intensity. The latter result may be used to develop a practical nonlinear transduction device for enhancing SNR.

Franaszek, M.; Simiu, E.
Crisis-Induced Intermittency and Melnikov Scale Factor.
Cracow Pedgogical Univ., Poland
National Institute of Standards and Technology, Gaithersburg, MD
Physics Letters A, Vol. 205, 137-142, September 11, 1995.

building technology; chaos; control theory; intermittency; melnikov function; nonlinear dynamical systems

We study the post-crucial behavior of a perturbed bistable Hamiltonian system to which the Melnikov approach is applicable under the assumption that the pertubation is asymptocially small. We examine the case of perturbations that are sufficiently large to cause chaotic transport between space regions associated with the system's potential wells. The main results are: (1) a small additional harmonic excitation can cause substantial changes in the system's mean residence time, and (2) the

dependence of the magnitude of these changes on the additional excitation's frequency is similar to the dependence on frequency of the system's Melnikov scale factor. We discuss the relevance of these results to the design of efficient, Melnikov-based open loop controls aimed at increasing the mean residence time for the stochastically excited counterpart of the system.

Franaszek, M.; Simiu, E.
Noise-Induced Snap-Through of a Buckled Column With Continuously Distributed Mass: A Chaotic Dynamics Approach.
National Institute of Standards and Technology, Gaithersburg, MD
International Journal of Non-Linear Mechanics, Vol. 31, No. 6, 861-869, 1996.

noise (sound); columns; chaotic dynamics approach equations; equations

For a spatially-extended dynamical system we illustrate the use of a chaotic dynamics approach to obtain criteria on the occurrence of noise-induced escapes from a preferred region of phase space. Our system is a buckled column with continuous mass, subjected to a transverse continuously distributed load that varies randomly with time. We obtain a stochastic counterpart of the Melnikov necessary condition for chaos - and snap-through - derived by Holmes and Mardsen for the harmonic loading case. Our approach yields a lower bound for the probability that snap-through cannot occur during a specified time interval. In particular, for excitation with finite-tailed marginal distribution, a simple criterion is obtained that guarantees the non-occurrence of snap-through.

Franaszek, M.; Simiu, E.
Stochastic Resonance; A Chaotic Dynamics Approach.
Cracow Pedagorgical Univ., Krakow, Poland
National Institute of Standards and Technology, Gaithersburg, MD
Physical Review E, Vol. 54, No. 2, 1298-1304, August 1996.

chaos; noise (sound)

For a class of multistable systems it follows from qualitative results of Melnikov theory that deterministic and stochastic excitations play equivalent roles in the promotion of chaos. We use such results to suggest: (1) a method for assessing the role of the noise spectrum in enhancing the signal-to-noise ratio (SNR), the most effective spectral shape being that for which the power is distributed closest to the frequency of the Melnikov scale factor's peak; (2) a method for more effective SNR enhancement than can be achieved by increasing the noise, wherein the noise is left unchanged and a harmonic excitation with frequency based on the system's Melnikov scale factor is added to the system. The effectiveness of our Melnikov-based methods is confirmed by numerical simulations. The principle of a practical and effective nonlinear transduction device for enhancing SNR is proposed and demonstrated numerically.

Frey, M.; Simiu, E.
Phase Space Transport and Control of Escape From a Potential Well.
Bucknell Univ., Lewisburg, PA
National Institute of Standards and Technology, Gaithersburg, MD
Physica D, Vol. 95, 128-143, 1996.

building technology; escape; control systems; dynamical systems; melnikov function; stochastic differential equations; stability; chaos

A framework for controlling a nonlinear dynamical system against escape from a potential well is presented based on reducing the phase space transport across the separatrix associated with the potential well. A bandlimited open-loop control with finite lag is considered for systems with weak additive stationary forcing including, specifically, the colored Gaussian case. The related multiplicative, closed-loop control problem is shown to reduce to an open-loop problem. A numerical example based on the Duffing oscillator is presented to illustrate the theory.

Frohnsdorff, G.; Martin, J. W.
Towards Prediction of Building Service Life: The Standards Imperative.
National Institute of Standards and Technology, Gaithersburg, MD
Durability of Building Materials and Components. International Conference, 7th. Chapter 147. Volume 2. Testing, Design and Standardization. Proceedings. May 19-23, 1996, Stockholm, Sweden, E. & F. N. Spon, New York, Sjostrom, C., Editor, 1417-1428 pp, 1996.

building materials; computer integrated knowledge systems; design life; performance concept; reliability based standards; service life prediction; standardization; standards

Twenty years ago, predicting the service lives of building materials and components was only a distant vision. Today, the possibility of incorporating predictions of service lives of materials and components into the design process for whole buildings is being given serious attention. The change in perspective is due to the sustained efforts of a small group of researchers and to developments in computerized knowledge systems and advances in building materials science. This paper reviews progress and suggests directions for further development. It emphasizes that standardization will be critical to acceptance of service life predictions in the building design process. The authors challenge researchers who want their work to have the greatest practical impact to participate in the standards-development process and help fashion the body of standards needed.

Fuller, S. K.; Petersen, S. R.
Life-Cycle Costing Manual for the Federal Energy Management Program. 1995 Edition.
National Institute of Standards and Technology, Gaithersburg, MD
NIST Handbook 135; 1995 Edition; 210 p. February 1996.
Available from National Technical Information Service
PB96-172317

benefit cost analysis; building economics; building technology; capital investment decisions; cost effectiveness; economic analysis; energy conservation; energy economics; life cycle cost analysis; public buildings; renewable energy; water conservation

Handbook 135 is a guide to understanding the life-cycle cost (LCC) methodology and criteria established by the Federal Energy Management Program (FEMP) for the economic evaluation of energy and water conservation projects and renewable energy projects on all federal buildings. It expands on the life-cycle cost methods and criteria contained in the FEMP rules published in 10 CFR 436, Subpart A, which applies to all federal agencies. The purpose of this Handbook is to facilitate the implementation of the FEMP rules by explaining the LCC method, defining the measures of economic performance used, describing the assumptions and procedures to follow in performing evaluations, giving examples, and noting NIST computer software available for computation and reporting purposes. An annual supplement to Handbook 135, "Energy Price Indices and Discount Factors for LCC Analysis", NISTIR 85-3273-X is also published by NIST to provide the current discount rate and discount factors needed for conducting an LCC analysis in accordance with the FEMP rules. This annual supplement is required when using Handbook 135. This new edition of Handbook 135 replaces the 1987 version. The new edition is extensively revised and organized around the key steps in an LCC analysis. There are no longer separate sections for new and existing buildings and for solar programs, as the methodology no longer distinguishes between these projects.

Fuller, S. K.; Petersen, S. R.
Life-Cycle Costing Workshop for Energy Conservation in Buildings: Student Manual.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5165-96; 233 p. October 1995.

energy conservation; costs; manuals; economics; computer programs; risk analysis; economic analyses

This report supersedes NISTIR 5165 (October 1994) This Student Manual for the "Life-Cycle Costing Workshop for Energy Conservation in Buildings" is a workbook for a two-day course on life-cycle cost (LCC) analysis developed by the National Institute of Standards and Technolgoy (NIST) for the U.S. Department of Energy, Federal Energy Management Program (FEMP). The methodology and procedures in this manual are consistent with 10 CFR part 436 and its amendments, which provide guidelines for the economic analysis of investments in energy conservation and renewable resources for federal buildings. The purpose of the workshop is to provide energy managers with the knowledge and skills they need to perform economic analyses of capital investments in energy conservation quickly and correctly. The analytical methodology presented is equally useful to government and private sector investments. Under the sponsorship of FEMP, the Office of Applied Economics (OAE) at NIST has conducted this workshop for both government and private sector participants several times each year for the past 10 years in various locations throughout the United States, as well as in Europe and Korea. Starting in 1995, FEMP and NIST have been encouraging "FEMP-qualified" LCC instructors to teach this same course, using this student manual as the basis of the course curriculum. The use of "FEMP-qualified" LCC instructors for this purpose can greatly expand the usage of LCC methodology to evaluate the cost effectiveness of energy conservation projects in the United States, both in government and in the private sector. This Student Manual is organized into 10 teaching modules and provides hard copies of the visual materials (slides) that are presented in each module. These visual materials are updated annually to reflect changes in the federal discount rate and projected energy price escalation rates used in federal LCC analyses of energy cosnervation projects. The visual materials are shown in the order that they are presented, in order to facilitate note taking by the students. Review materials for each module are presented at the end of the module, as well as an exercise based on the lecture. We recommend that the students work in small groups to solve these exercises rather than working individually

G

Gann, R. G.
Developing Materials Fire Response Information for Assessing Fire Hazard and Risk.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Risk and Hazard Assessment Symposium: Research and Practice - Bridging the Gap. Proceedings. National Fire Protection Research Foundation. June 26-28, 1996, San Francisco, CA, 286-294 pp, 1996.

fire risk; hazard assessment; flammability measurements; product safety

In the presence of a fire, materials and products may respond by producing heat and flames, particulate smoke, and toxic and contaminant gases. This paper summarizes the contributions of products to the growth of fire hazard, offers a framework for reducing the multiple constraints on materials fire specification, characterizes the properties to be measured, and identifies research priorities to bring this concept to reality. This approach offers enhanced freedom for the development of new materials whose proliferation will contribute to an improved degree of fire safety.

Gann, R. G.
NIST Research on Less Flammable Materials.
National Institute of Standards and Technology, Gaithersburg, MD
SAMPE Journal, Vol. 32, No. 3, 16-20, May/June 1996.

flammable materials; fire safety; research facilities; safety engineering; fire science

A principal objective of the NIST Fire Research Program is supporting the development by U.S. manufacturers of a new generation of building and furnishing materials and products that contribute less to a fire, maintain their fire safety performance over the product life, and are environmentally friendly. This paper describes the NIST roles in fire safety science and engineering, as well as research projects currently underway on less fire-prone materials and products.

Gann, R. G.; Anderson, T. L.; Bomba, S. J.; Cemenska, R. A.; DiTomas, E. E.; Duscha, L. A.; Ehrenkrantz, E.; Goldberg, B.; McGinnis, C. I.; Paulson, B. C., Jr.; Raufaste, N. J., Jr.; Reinschmidt, K. F.; Rosenfeld, A. H.
Innovation in the Japanese Construction Industry: A 1995 Appraisal.
National Institute of Standards and Technology, Gaithersburg, MD
Fluor Daniel Technologies, Irvine, CA
Johnson Controls, Inc., Milwaukee, WI
Caterpillar Inc., Peoria, IL
Turner Corp.
New Jersey Institute of Technology, Newark
National Association of Home Builders, Washington, DC
Construction Industry Institute, Austin, TX
Stanford Research Inst., Menlo Park, CA
Stone and Webster
Department of Energy, Washington, DC
NIST SP 898; 265 p. March 1996.
Available from National Technical Information Service
PB96-177373
Available from Government Printing Office
SN003-03401-1

construction; industries

As part of a national effort to benchmark the competitiveness of U.S. industries, this study evaluates the state of technology and innovation in the Japanese construction industry. That industry is large, solid and progressive, leading the world in the size of its construction industry relative to GDP, in the modernity and quality of its constructed facilities, in the size and quality of its physical research laboratories, and in its private and public investments in construction research and development. The Japanese have built an integrated approach toward incorporating new technologies into their design and construction projects and lead in such areas as large-scale bridges, tunnels, soft-ground construction, congested area construction, high performance construction materials, automated "jack-up" erection techniques for high-rise buildings, and computer visualization of residences for prospective buyers. The United States leads in computer integration of design and construction, the economy of constructed facilities, and global positioning systems. The Japanese are generally faster in providing nationalwide acceptance of innovations. The Japanese industry has taken strong measures to increase the pace of its internationalization, but still lags both United States and European competitors in market penetration, in large part due to the currently strong yen. Recent economic pressures have reduced the Japanese allocation of resources to construction R&D. The United States and its construction industry can benefit from the practices and innovations developed by the Japanese. While a direct transfer of the Japanese R&D approach and the emerging technologies may not always be feasible, the opportunities for modified application and the potential value of increased U.S. investment in construction R&D should not be overlooked. The U.S. industry would derive considerable benefit from the establishment of a U.S. public/private sector program both to conduct multidisciplinary R&D and to efficiently disseminate evaluated technology focussed in the construction field.

Garboczi, E. J.; Bentz, D. P.
Modelling of the Microstructure and Transport Properties of Concrete.
National Institute of Standards and Technology, Gaithersburg, MD
Construction and Building Materials, Vol. 10, No. 5, 293-300, 1996.

building technology; concretes; diffusivity; electrical conductivity; interfacial zone; length scales; models; percolation; microstructure; multi-scale

Theoretical understanding of how the properties and performance of cement-based materials relate to microstructure is complicated by the large range of relevant size scales. Processes occurring in the nanometre-sized gel pores ultimately affect

the performance of these materials at the structural level of metres and larger. One approach to alleviating this complication is the development of a suite of models, consisting of individual digital-image-based structural models for the calcium silicate hydrate gel at the nanometre level, the hydrated cement paste at the micrometre level, and a mortar or concrete at the millimetre to metre level. Computations performed at one level provide input properties to be used in simulations of performance at the next higher level. This methodology is demonstrated for the property of ionic diffusivity in saturated concrete. In addition, the ideas of percolation theory are shown to unify microstructure and many physical phenomena at various length scales in concrete.

Garboczi, E. J.; Bentz, D. P.
Multi-Scale Picture of Concrete and Its Transport Properties: Introduction for Non-Cement Researchers.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5900; 52 p. October 1996.
Available from National Technical Information Service
PB97-115802

building technology; cement paste; computer modeling; concretes; microstructure; mortar; percolation; transport properties

Concrete is a multi-length scale composite material. From the nanometer to the millimeter scale, it is a random composite, and a different random composite at each length scale. Percolation processes play a key role in the microstructure of concrete and help to describe the overall dependence of transport properties like ionic diffusivity on the microstructure. Computer models have been developed to describe the microstructure and transport properties, as the randomness of the material precludes most (but not all) analytical formulations. The overall description of concrete, over six orders of magnitude of length scales, in terms of computer models, percolation theory, and composite ideas is of interest to those studying other random materials as well, like ceramics and rocks. This report is written to present the ideas for concrete in such a way so as to be accessible to the non-cement researcher. It is hoped that these ideas will prove to be useful in other materials.

Garboczi, E. J.; Douglas, J. F.
Intrinsic Conductivity of Objects Having Arbitrary Shape and Conductivity.
National Institute of Standards and Technology, Gaithersburg, MD
Physical Review E, Vol. 53, No. 6, 6169-6180, June 1996.

electrical resistivity; arbitrary shape; conductivity

We study the electrical conductivity sigma of a dispersion of randomly oriented and positioned particle inclusions having common shape or conductivity, suspended in an isotropic homogeneous matrix of conductivity. For this problem, the mixture conductivity is a scalar and we concentrate on the leading order concentration virial coefficient, the "intrinsic conductivity." Results for [sigma] are summarized for limiting cases where there is a large mismatch between the condictivities of the inclusions and the suspending matrix. For a general particle shape, we then treat the more difficult case of arbitrary relative conductivity through the introduction of a Pade approximant that incorporates (exact or numerical) information for limits. Comparison of this approximation for [sigma (delta)] to exact and finite element calculations for a variety of particle shapes in two and three dimensions shows excellent agreement over the entire range of delta. This relation should be useful for inferring particle shape and property information from conductivity measurements on dilute particle dispersions. The leading order concentration virial coefficient for other mixture properties (thermal conductivity, dielectric constant, refractive index, shear modulus, bulk modulus, viscosity, etc.) are equally well described by a similar Pade approximant.

Gilman, J. W.; Lomakin, S.; Kashiwagi, T.; VanderHart, D. L.; Nagy, V.
Char Enhancing Approaches to Polymer Flammability: The Effect of Radicals on Magic Angle Spinning 13C NMR of Chars.
National Institute of Standards and Technology, Gaithersburg, MD

NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 133-134 pp, 1996.
Available from National Technical Information Service

fire research; fire science; char; flammability; char formation; additives

Additives that increase the amount of charcoal-like residue or carbonaceous char that forms during polymer combustion are very effective fire retardants. However, very little is understood about the detailed struture of char or how it forms. Our research efforts focus on reducing polymer flammability by promoting char formation. Char formation reduces the amount of small volatile polymer pyrolysis fragments, or fuel, available for burning in the gas phase; this in turn reduces the amount of heat released and feedback to the polymer surface. The char also insulates the underlying polymer, due to its low thermal conductivity, and reradiates externally impinging energy away from the polymer. The char must also function as a mass transport barrier, by physically delaying the volatilization of decomposition products and or trapping decomposition products through chemical reaction. The physical structure of the char is important in this role. Foamy char structure appears to be more fire resistant than brittle, thin char. This char enhancing approach is most successful when the polymer chars rapidly and early in the burning process. To be useful the charring process must occur at a temperature above the processing temperature but below the temperature where rapid gasification of the polymer to combustible fuel occurs.

Gilman, J. W.; Simiu, E.
Polymer Film Applied to Glass: Effectiveness at Mitigating Damage from Flying Glass Due to Explosions.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5779; 16 p. January 1996.
Available from National Technical Information Service

glass; explosions; damage; blasts; building technology; coatings; earthquakes; film; hurricanes; impacts; polymers

Prompted by the terrorist attack in Oklahoma City, the Department of Justice has recommended the application of polymeric film to exterior glass in Federal buildings to reduce the possibility of damage resulting from flying glass from explosive blasts. Before deciding to undertake an extensive retrofit of all Federal facilities, the General Services Administration (GSA) requested the National Institute of Standards and Technology's (NIST) Building and Fire Research (BFRL) to search pertinent English language bibliographic databases for research reports, test data or other available information in the literature on polymer film applied to monolithic glass. The scope of the literature search included: 1) blast effects on architectural glass; 2) performance of polymeric film on glass under blast conditions; and 3) the application, durability and maintainability of polymeric films on glass. This report does not address or attempt to assess the performance characteristics of any other glazing product, composite or application. The documentation available to date does not contain statistically significant evidence indicating that the use of polymer film as a retrofit on the daylight surface of monolithic glass measurably reduces the possibility of damage due to flying glass from explosive blasts.

Glaser, S. D.; Leeds, A. L.
Estimation of System Damping at the Lotung Site by Application of System Identification.
Colorado School of Mines, Golden, CO
NIST-GCR-96-700; 195 p. August 1996.
Available from National Technical Information Service
PB96-214697

system identification; earthquakes; system damping; seismic design

Possibly the best set of data for earthquake excitation of soils exists for the test site operated by the Taiwan Power Company in conjunction with the Electric Power Research Institute (EPRI) at Lotung, Taiwan. At this site, two locations are instrumented with three-component accelerometers at depths of 47 m, 17 m, 11 m, 6 m, and at the surface. One array is in the free-field, while the other is adjacent to a one-quarter scale nuclear containment vessel. The site is also well instrumented

with piezometers at various depths and locations. The simplified soil profile consists of 30 m to 35 m of silty sand and sandy silt with some gravel, overlaying a thick clay and silt deposit. The water table is within half a meter of the ground surface. This area is seismically active, and strong shaking generated by many earthquakes exhibiting a wide range of magnitudes have been recorded since 1986. For this study, the modal frequencies and damping ratios were calculated for events 3,4,7,8,9,10,12 and 16 with local magnitudes ranging from 4.5 to 7.0. The modal frequencies and damping ratios calculated are examined for the effect of local energy intensity and soil structure interaction. Modal frequencies are seen to decrease with increasing intensity once a certain threshold of acceleration/intensity is reached. This result is consistent with the data obtained by other authors using different techniques. For the 0-6 m interval the decrease in frequency with event energy is less pronounced under a model containment structure than in the free field. This soil-structure effect is increasingly diminished with depth and absent by the 17-47 m interval. Calculated damping values demonstrate an expected increase with input seismic energy. For the 0-6 m and 6-11 m intervals the damping values are higher under the model structure than in the free field. This distinction is completely missing in the 17-47 m results. The transition to non-linear behavior, while less pronounced with increasing depth, consistently occurs above a peak acceleration of 0.05 g or Arias Intensity of 100 m/sec. The results clearly indicate a degree of non-linear response over the intervals studied. Evidence of a decrease in specific interval fundamental frequency and an accompanying general trend of increased damping with higher seismic energy are clear. Comparison of the results of this study with previous work considered with the inherent superiority of parametric modeling for transient and/or non-stationary time series such as earthquakes indicate that system identification is a more robust method for identifying fundamental frequencies and damping values for layers of earth materials when borehole information is available.

Glaser, S. D.; Leeds, A. L.
Preliminary Processing of the Lotung LSST Data.
Colorado School of Mines, Golden, CO
NIST-GCR-96-690; 57 p. March 1996.
Available from National Technical Information Service
PB96-165972

signals; data processing; earthquakes

Possibly the best set of data for earthquake excitation of soils exists for the test site operated by the Electric Power Research Institute (EPRI) and the Taiwan Power Company at Lotung, Taiwan. At this site, two locations are instrumented with three-component accelerometers at depths of 47, 17, 11, 6 meters, and at the surface. One array is in the free-field while the other is adjacent to a one-quarter scale nuclear containment vessel. The site is also well instrumented with piezometers at various depths and locations. The simplified soil profile consists of 30 to 35 m of silty sand and sandy silt with some gravel, overlaying a thick clay and silt deposit. The water table is within half a meter of the ground surface. This area is seismically active, and strong shaking generated by many earthquakes exhibiting a wide range of magnitudes have been recorded since 1986. This report summarizes the data and signal processing that was done to the EPRI Lotung data at the Colorado School of Mines. The over 2000 files were organized into MATLAB experiments by event. The provided acceleration data were carefully doubled integrated to yield velocity and displacement time history records. The data are now in proper format to begin system identification analysis.

Gott, J. E.; Notarianni, K. A.
Analysis of High Bay Hangar Facilities for Detector Sensitivity and Placement.
Department of the Navy, Alexandria, VA
National Institute of Standards and Technology, Gaithersburg, MD
Society of Fire Protection Engineers (SFPE). Honors Lecture Series. Proceedings. May 20, 1996. Engineering Seminars: Fire Protection Design for High Challenge or Special Hazard Applications. Proceedings. May 20-22, 1996, Boston, MA, 1-8 pp, 1996.

fire protection engineering; fire protection; hangars; aircraft fuels; heat release; large scale fire tests; flame detectors; sprinklers; fire research

Existing building and fire codes in the United States offer little or no guidance in the design of fire protection systems in high bay spaces due to the lack of scientific data. Timely detection of a fire is more difficult in large spaces due to the distance

heat and other products of combustion must travel to sprinklers or detectors. Possible stratification poses an additional challenge in selecting the optimal location of detectors. The focus of this paper is on the full-scale experiments conducted by NAVFAC and NIST which were designed to assist the Navy in reevaluating its criteria for the protection of high bay aircraft hangars. Previous studies conducted in 15 m and 30.5 m hangars used isopropyl alcohol, involved only one fire size, and were conducted with the hangar doors only in the closed position. The NAVFAC/NIST experiments included numerous fire sizes, aviation fuels, and both open and closed doors. Also participating in these experiments were five fire protection industry sponsors representing the fire alarm and automatic sprinkler industries, representatives from each branch of the U.S. Department of Defense, and representatives from select NFPA technical committees.

Gross, J. G.
Developments in the Application of the Performance Concept in Building.
National Institute of Standards and Technology, Gaithersburg, MD
Applications of the Performance Concept in Building. CIB-ASTM-ISO-RILEM 3rd International Symposium. Volume 1. Proceedings. National Building Research Institute. December 9-12, 1996, Tel-Aviv, Israel, National Building Research Institute, Haifa, Israel, Becker, R.; Paciuk, M., Editors, 1/1-11 pp, 1996.
codes; performance concept; standards
The performance approach in building is not new, it is traced back thousands of years. The performance concept is widely acclaimed and is applicable to both building procurement (design and construction) and to regulation (control), but has not been widely applied worldwide. This presentation provides a summary of the history of the performance concept in building, identification of some problems and limitations to its application and how the performance concept is dependent upon the more traditional prescriptive approach for practical application. It is suggested that, now is the time for rapid increases in application because numerous nations of the world are committing to applying the performance concept to building regulation which will permit and encourage application to innovative building design and construction.

Grosshandler, W. L.; Yang, J. C.; Cleary, T. G.
Aerosol and SPGG Technology Fire Suppression Screening Methods.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 59-60 pp, 1996.
Available from National Technical Information Service
fire research; fire science; fire suppression; aerosols; solid propellants; halon alternatives
The search for alternatives to halons for fire suppression applications has identified not only new compounds which have physical properties similar to the bromochlorofluorocarbonfamily, but also inert gaseous agents that are released from a solid state and condensed phase agents that may be misted or generated pyrotechnically. Industry is already investigating innovative ways that these multiple technologies can be blended or hybridized to create an optimum fire fighting agent/release mechanism for specific applications. The traditional cup burner method is unable to evaluate these not-in-king replacement systems. Two new concepts for testing liquid aerosol and solid propellant gas generator (SPGG) fire suppression technologies are presented here.

H

Hamins, A.; Kashiwagi, T.; Buch, R. R.
Characteristics of Pool Fire Burning.
National Institute of Standards and Technology, Gaithersburg, MD
American Society for Testing and Materials (ASTM). Fire Resistance of Industrial Fluids. Proceedings. ASTM STP 1284. June 20, 1995, Indianapolis, IN, ASTM, Philadelphia, PA, Totten, G. E.; Reichel, J., Editors, 15-41 pp, 1996.

pool fires; burning rate; flame height; radiative heat transfer

The structure and energetics of hydrocarbons burning in a pool fire configuration are reviewed. Examples of non-hydrocarbons are also presented. The character and structure of pool fires are discussed with special regard to the flame shape, flame pulsation frequency, flame height, and the detailed flame structure. An enthalpy balance about the flame considers enthalpy losses to the surroundings due to radiation, convection of sensible heat, and combustion efficiency considerations. The power radiated from a flame as a function of burner diameter is discussed. An enthalpy balance about the pool surface partitions the heat feedback into conduction, convection, and radiation. This enthalpy is part of a positive feedback loop which goes to vaporize the fuel. Differences between field and zone models are discussed.

Hung, L. S.; Yao, S. C.
Experimental Investigation of the Water Mist Impacting Phenomenon on Horizontal Wires.
Carnegie-Mellon Univ., Pittsburgh, PA
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 13-14 pp, 1996.
Available from National Technical Information Service

fire research; fire science; water mist; wires; droplets

The phenomenon of water mist impacting on horizontal wires has been experimentally investigated. This process is relevant to the water mist intercepting and penetrating into the openings of compartment. The impaction of droplets on wires provides a basis for the understanding of the similar processes on more complicated structures such as screens.

Hung, L. S.; Yao, S. C.
Numerical Studies on the Deposition and Transport of Water Mist Normal to a Horizontal Plate.
Carnegie-Mellon Univ., Pittsburgh, PA
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 15-16 pp, 1996.
Available from National Technical Information Service

fire research; fire science; water mist; numerical analysis; droplets

The deposition and transport of fine droplets in a water mist flowing downwards onto a horizontal plate are modeled numerically in this study. It reveals the aerodynamic process of droplets impacting to the top of a compartment or an object. The nature of the droplets transport phenomenon in the wake region behind an object is also investigated.

Huynh, H.; Raghavan, D.; Ferraris, C. F.
Rubber Particles From Recycled Tires in Cementitious Composite Materials.
Howard Univ., Washington, DC
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5850 R; 23 p. May 1996.

building technology; rubber concrete; rubberized mortar; plastic shrinkage; fibrous rubber; strength; recycled rubber tires

A possible method for recycling used automobile and truck tires could be to comminute them and incorporate the rubber particles into concrete. In a preliminary investigation, mechanical properties of mortar containing ground or shredded tires were evaluated. In this study, two different shapes of rubber particles were used as constituents of mortar : granules of about 2 mm diameter and shreds having two sizes which were, nominally, 5.5 mm x 1.2 mm and 10.8 mm x 1.8 mm (length x diameter). It was found that addition of rubber granules led to a decrease in both compressive and flexural strengths of mortar. On the other hand, the addition of rubber shreds improved some of the properties of the mortar. In particular, the crack width and crack length due to plastic shrinkage were reduced for mortar containing the 10.8 x 1.8 mm rubber shreds compared with a control mortar without rubber particles. The mortar containing rubber shreds showed workability comparable to that of a mortar without rubber particles. A mortar containing 25.4 mm long and 15 mm diameter polypropylene fibers showed poor workability compared with a mortar containing rubber fibers. Although further studies are necessary, it appears that the incorporation of shredded rubber could be beneficial for reducing plastic shrinkage crack development of mortar and probably concrete.

J

Jason, N. H.
Locating Fire Information.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 691-698 pp, 1996.

fire safety; design applications; bibliographies; databases; computer systems; fire research

Locating the best reference or answer to a specific question in fire science may be difficult. There are standard reference books and journals that may be used. New sources continue to become available, in particular, electronic tools that are available internationally. This discussion will center on developing an information tool kit identifying resources from the print media, multitopic bibliographic databases, fire databases, and the World Wide Web, to enable one to find the answer from either the traditional print media or an electronic resource.

Johnsson, E. L.
Study of Technology for Detecting Pre-Ignition Conditions of Cooking-Related Fires Associated With Electric and Gas Ranges and Cooktops.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 111-112 pp, 1996.

Available from National Technical Information Service

fire research; fire science; stoves; preignition; appliances

In 1994, 3,425 deaths, 19,475 injuries, and $4.2 billion in property damage were caused by 438,000 home fires in the United States. The National Fire Protection Association estimated that between 1988 and 1992, range/oven appliance fires averaged about 20% of all home fires and were responsible for approximately 20% of the injuries, 5% of the deaths, and 5% of the property loss associated with home fires. A majority of these range/oven fires involved food. The overall objective of the Consumer Product Safety Commission's Range Cooking Fire Project is to reduce the number of cooling-related fires in homes. The objective of this testing effort was to determine the possibility of detecting hazardous range-cooked food situations to allow alarm or shutoff of the range before ignition occurs. Feasibility of such a detection system also requires the availability of effective technology and its ability to differentiate normal and hazardous situations and thus not alarm falsely.

Jones, W. W.

Evolution of HAZARD, the Fire Hazard Assessment Methodology.

National Institute of Standards and Technology, Gaithersburg, MD

Fire Risk and Hazard Assessment Symposium: Research and Practice - Bridging the Gap. Proceedings. National Fire Protection Research Foundation. June 26-28, 1996, San Francisco, CA, 392-406 pp, 1996.

fire risk; hazard assessment; methodology; computer programs; fire models; egress

The United States alone spends over $700B per on new and renovated construction. About 20% of this is to assure safety from unwanted fires, which includes the cost of insurance, to make families whole after fires, to recover from business loss and so forth. This is an enormous cost to endure every year. Combined with a growing construction market in other countries, this presents a major opportunity for the introduction of new fire safe products to the building and transportation industries and new products such as advanced detectors and suppression systems and fire fighting equipment for the fire protection industry. These industries need measures of performance for their products and mechanisms to show that these products can be safely and quickly introduced. Performance based fire standards are currently under development to augment prescriptive standards around the world. The intent of performance based standards is to provide flexibility in maintaining accepted fire safety from unwanted fires with new competitive products while providing an opportunity for saving lives, reducing property loss, at the same time buying a reduction in the cost of design, construction, maintenance and liability coverage. In order to derive this benefit it is necessary to have tools to evaluate building systems performance which then provide a metric for the effectiveness of design and material use.

Jones, W. W.

Fire Hazard Assessment Methodology.

National Institute of Standards and Technology, Gaithersburg, MD

NISTIR 5836; 10 p. May 1996.

Available from National Technical Information Service

fire hazards; hazard assessment; fire models; computer models; methodology

The United States alone spends about $850B per year on new and renovated construction. About 1/5 of this is to assure safety from unwanted fires. This presents a major opportunity for the introduction of new fire safe products to the building and transportation industries and new products such as advanced detectors and suppression systems and fire fighting equipment for the fire safety industry. These industries need measures of performance for their products and mechanisms to show that these products can be safely and quickly introduced. In order to derive this benefit it is necessary to have tools to evaluate building systems performance which then provide a metric for the effectiveness of design and material use. The Fire Hazard Assessment Methodology provides the first component of a performance evaluation system.

Jones, W. W.
Modeling Fires - The Next Generation of Tools.
Worcester Polytechnic Inst., MA
Society of Fire Protection Engineers and WPI Center for Firesafety Studies. Computer Applications in Fire Protection Engineering. Technical Symposium. Proceedings. Final Program. June 20-21, 1996, Worcester, MA, 13-18 pp, 1996.

fire protection engineering; zone models; fire models; computational fluid dynamics

This paper discusses fire modeling and how it is changing. The examples will be based on the tools that are being developed at NIST, in the Building and Fire Research Laboratory, but the general concepts are universally true. Modeling of fire, in the sense most understand it, is a relatively new discipline. Although Kawagoe first proposed that one might be able to estimate the outcome of a fire scenario in the early fifties, and Emmons actually tried to make it happen in the seventies, it wasn't until the early eighties that the science of fire and engineering applications became popular. Much of the impetus in the United States came from the National Commission on Fire Prevention and Control, America Burning, after which the Center for Fire Research was established. Subsequently the Federal Trade Commission developed a formal complaint that small scale testing did not adequately address the real behavior of materials. This led to an interest in tests which measured fire performance properties rather than simple classifications.

Jones, W. W.
Progress Report on Fire Modeling and Validation.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5835; 12 p. May 1996.
Available from National Technical Information Service

fire models; validation

The nations of the world are moving toward performance based building code standards which will establish a level of safety or risk rather then the traditional prescriptive codes which specify the performance of components. Performance evaluations can then use trade offs between many factors to provide the required level of safety. Computer models are the means to ascertain the performance of buildings built with new materials and new contents. As these models progress and become more entrenched in the regulatory system, it is paramount there be a continual effort to insure their validity. The accuracy of the models of individual phenomena is, and should be, addressed during development. However, the interaction of various parts of the system are not always well understood. This paper is part of the continuing effort to test the complete system model with full scale and real scale tests and experiments. The International Standards Organization (ISO), together with the Conseil International du Batiment (CIB), is establishing a framework for deciding on the appropriateness of a model to meet the requirements of those who wish to use them in predicting the environment in a building. This paper discusses the status of this work and lays out the time table for the completion of this effort, leading to a proposal for an ISO standard.

Jones, W. W.; Bailey, J. L.; Tatem, P. A.; Forney, G. P.
Comparison of CFAST Predictions to Real Scale Fire Tests.
National Institute of Standards and Technology, Gaithersburg, MD
Naval Research Laboratory, Washington, DC
Institut de Securite. Fire Safety Conference on Performance Based Concepts. Proceedings. October 15-17, 1996, Zurich, Switzerland, 25/1-14 pp, 1996.

fire safety; fire codes; building codes; standards; fire tests; computer models; fire behavior; fire models; zone models; equations; experiments; instruments

This paper describes a new algorithm of the Consolidated Fire Growth and Smoke Transport (CFAST) fire model and compares to data from real scale fire tests conducted onboard the ex-USS SHADWELL, the Navy's R&D Damage Control Platform. The new phenomenon modeled in this work is the conduction of heat in the vertical direction. The SHADWELL tests chosen for validation purposes were part of the Internal Ship Conflagration Control (ISCC) program. The work focusses on the four

compartments of the ship which were vertically aligned. The temperatures of three of the compartments and the decks between them were compared with model predictions. Predictions compared very closely with experimental results for all compartments, although the temperature rise in the topmost compartment was barely above ambient.

K

Kaetzel, L. J.; Padilla, S.
Electronic Commerce and Intellectual Property on the Internet: An Overview of the Concepts.
National Institute of Standards and Technology, Gaithersburg, MD
Steel Structures Painting Council (SSPC). Technologies for a Diverse Industry. SSPC 1996 Seminars. Proceedings. SSPC 96-08. November 17-21, 1996, Charlotte, NC, 184-193 pp, 1996.
coatings; coating materials; electronic commerce; electronic data interchange; intellectual property; Internet

Business use of the Internet has increased dramatically. New technologies and procedures involving Intellectual Property and Electronic Commerce will revolutionize the marketing of products and other business transactions. Intellectual Property Assets are expensive to develop and with electronic mediums can be disseminated widely, with or without the owner's approval, in minimal time and minimal cost. Electronic Commerce transactions must be secure and must be integrated into an organization's marketing and information dissemination procedures. Without controls in place the assets and information can be pilfered or misused without the owner's knowledge. The following is a brief discourse into the subject matter and will provide a beginning point into understanding these two complex subjects.

Kandhal, P.S.; Wu, Y.; Parker, F., Jr.; Spellerberg, P. A.
Precision of Marshall Stability and Flow Test Using 6-in. (152.4-mm) Diameter Specimens.
Auburg Univ., AL
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Testing and Evaluation (JTEVA), Vol. 24, No. 1, 20-25, January 1996.
stability; flow measurement; asphalt; large stone mixes; marshall stability; marshall flow; percent voids; data analysis; precision statement

Earlier studies have shown that the repeatability of Marshall stability, flow, and air voids content measurements on 6-in. (152.4-mm) diameter specimens of large stone mixes is better than the repeatability on 4-in. (101.6-mm) diameter specimens. A round robin study involving twelve participating laboratories was conducted to provide information for developing a precision statement for the ASTM Test Method for Resistance to Plastic Flow of bituminious Mixtures Using Marshall Apparatus (6 inch-Diameter Specimen) (D 5581). Difference two-sigma (d2s) limits were developed to determine acceptable single and multilaboratory differences for bulk specific gravity, percent voids, Marshall stability, and Marshall flow measurements. Analysis of other data collected during the study indicated that stability and flow measurements are not sensitive to minor differences in various 6-in. (152.4-mm) diameter breaking heads currently in use.

Kao, J. Y.; Kelly, G. E.
Factors Affecting the Energy Consumption of Two Refrigerator-Freezers.
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions, Vol. 102, No. 2, 1-11, 1996.
energy affecting factors; energy consumption; energy consumption test; refrigerator-freezer; refrigerator-freezer temperature setting

Two refrigerator-freezers, one with a top-mounted freezer and one with side-by-side doors, were tested in the laboratory to determine the sensitivity of their energy consumption to various operational factors. Room temperature, room humidity, door openings, and the setting of the anti-sweat heater switch were the factors examined. The results indicated that the room temperature and door openings had a significantly greater effect on energy consumption than the other two factors. More detailed tests were then performed under different room temperature and door-opening combinations. The relationship of door openings and the equivalent test room temperature was established. Finally, the effect on energy of different temperature settings was studied. Test results are presented and discussed.

Kaplan, C. R.; Shaddix, C. R.; Smyth, K. C.
Computations of Enhanced Soot Production in Time-Varying CH4/Air Diffusion Flames.
Naval Research Laboratory, Washington, DC
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 106, No. 4, 392-405, September 1996.
soot; diffusion flames; chemical reactions; equations

Recent experimental measurements of soot volume fraction in a flickering CH4/air diffusion flame show that for conditions in which the tip of the flame is clipped, soot productions is ~ 5 times greater than that measured for a steady flame burning with the same mean fuel flow velocity. This paper presents time-dependent numerical simulations of both steady and time-varying CH4/air diffusion flames to examine the differences in combustion conditions which lead to the observed enhancement in soot production in the flickering flames. The numerical model solves the two-dimensional, time-dependent, reactive-flow Navier-Stokes equations coupled with submodels for soot formation and radiation transport. Qualitative comparisons between the experimental and computed steady flame show good agreement for the soot burnout height and overall flame shape except near the burner lip. Quantitative comparisons between experimental and computed radial profiles of temperature and soot volume fraction for the steady flame show good to excellent agreement at mid-flame heights, but some discrepancies near the burner lip and at high flame heights. For the time-varying CH4/air flame, the simulations successfully predict that the maximum soot concentration increases by over four times compared to the steady flame with the same mean fuel and air velocities. By numerically tracking fluid parcels in the flowfield, the temperature and stoichiometry history were followed along their convective pathlines. Results for the pathline which passes through the maximum sooting region show that flickering flames exhibit much longer residence times during which the local tempeatures and stoichiometries are favorable for soot production. The simulation also suggest that soot inception occurs later in flickering flames, and at slightly higher temperatures and under somewhat leaner conditions compared to the steady flame. The integrated soot model of Syed et al. which was developed from a steady CH4/air flame, successfully predicts soot production in the time-varying CH4/air flames.

Kapoor, K.; Jaluria, Y.
Flow and Heat Transfer Due to a Buoyant Ceiling Jet Turning Downward at a Corner.
State University of New Jersey, New Brunswick
Journal of Heat Transfer, Vol. 118, No. 1, 38-46, February 1996.
corners; heat transfer; ceiling jets; buoyant flow

An experimental investigation has been carried out on the flow and heat transfer characteristics of a horizontal buoyant ceiling jet that turns downward at a corner to yield a vertical negatively buoyant wall flow. Such flow situations are frequently encountered in thermal energy storage, in electronic systems, and in room fires. However, not much work has been done to understand the basic mechanics governing such flows, particularly the flow near the corner. In this study, a two-dimensional jet of heated air is discharged adjacent to the lower surface of an isothermal horizontal plate. An isothermal vertical plate is attached at the other end of the horizontal surface, making a right angle corner. The vertical penetration distance of the resulting downward flow is measured and is related to the inflow conditions, particularly to the temperature and velocity at the jet discharge. This penetration distance is found to increase as the distance between the discharge location and the corner is reduced and also as the relative buoyancy level in the inlet flow is decreased. Velocity and temperature measurements are also carried out over the flow region. These indicate that the ceiling flow separates from the horizontal surface just before reaching the corner and then reattaches itself to the vertical wall at a finite distance vertically below the corner. The local surface heat flux measurements show a minimum in the heat transfer rate before the turn, along with a recovery in the heat

transfer rate after the turn and the existence of a small recirculation zone near the corner. The net entrainment into the flow and heat transfer rate to the solid boundaries are also measured and correlated with the jet discharge conditions.

Kashiwagi, T.; Gilman, J. W.; McGrath, J. E.; Wan, I. Y.
Flammability Properties of Phosphine Oxide Copolymers and of Commodity Polymers With New Flame Retardant Additives.
National Institute of Standards and Technology, Gaithersburg, MD
Virginia Polytechnic Institute and State Univ., Blacksburg
Tomorrow's Trends in Fire Retardant Regulations, Testing, Applications and Current Technologies. Fall Conference. Proceedings. October 13-16, 1996, Naples, FL, 1-23 pp, 1996.
flame retardants; flammability; nylon; phosphine oxide; copolymers; additives

Several different phosphineoxides, triphenylphosphineoxide, diphenylphosphineoxide, and trihydroxylpropylphosphineoxide, are added into nylon 6,6 by copolymerization and by blending. The flammability properties of these samples are measured in the Cone Calorimeter. The results show that the addition of any of these phosphine oxides to nylon 6,6 reduces the heat release rate significantly but increases the amount of CO and soot particles. Although small amounts of char are formed with the phosphine oxides, the flame retardant site appears to be mainly in the gas phase. No significant difference in flammability properties is observed between the copolymer samples and the blended sample. A small quantity of silica gel with K2CO3 as an additive reduces heat release rate of many different polymers and forms carbonaceous char for PP, PMMA, nylon 6,6 and also significantly enhances char yields of cellulose and PVA. The solid-state NMR data of char formed from PVA with silica gel/K2CO3 show increase in aromaticity in the char compared with in the char generated from PVA only.

Kashiwagi, T.; Hamins, A.; Steckler, K. D.; Gilman, J. W.
Polymer Combustion and New Flame Retardants.
National Institute of Standards and Technology, Gaithersburg, MD
BCC Conference on Flame Retardancy, Seventh (7th) Annual. Proceedings. Business Communications Co., Inc. (BCC). May 20-22, 1996, Stamford, CT, 1-26 pp, 1996.
flame retardants; char; flame spread; heat release; pool flames; combustion; vapor phases; cone calorimeters

The combustion of polymers is a complex coupled process characterized by energy feedback from a flame to the polymer surface and subsequent gasification of the polymer to generate combustible degradation products. Energy feedback characteristics for two different burning configurations, pool burning and vertical wall burning, are discussed. Thermal degradation of polymers and heat transfer in polymer samples are briefly discussed in order to determine polymer gasification rates at specified external heat fluxes. Transient burning rates of two polymeric materials, PMMA and Douglas Fir, are calculated in a pool flame configuration for two different diameters and the predicted results are compared with the experimental data. A similar comparison is made for upward flame spread in the corner of a room. To improve the fire performance of polymers, use of a nonhalogenated char-forming flame retardant is suggested, and its benefits are discussed. The fire performance of a newly developed char forming flame retardant additive combination in a variety of polymers is described. Although its flame retardant mechanism has been studied by analyzing the char structure in the presence of the additives using solid-state NMR, at present it is not clearly understood.

Kedzierski, M. A.
Enhancement of R123 Pool Boiling by the Addition of N-Hexane.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5780; 42 p. March 1996.
Available from National Technical Information Service

PB96-165956

building technology; additives; enhanced heat transfer; fluid heating; GEWA-T; pool boiling; R123

This paper presents the heat transfer data used to file international patent WO 94/18282. The data consisted of pool boiling performance of a GEWA-TTM surface for three fluids: (1) pure R123, (2) R123/n-hexane (99/1), and (3) R123/n-hexane (98/2). The heat flux and the wall superheat were measured for each fluid at 277.6 K. A (47 + 7)% increase over the pure R123 heat flux was achieved with the addition of 1% mass hexane to R123. Similarly, the R123/hexane (99/2) mixture gave a maximum percent heat flux enhancement over pure R123 of (29 + 7)%. The boiling was filmed with a 16 mm high-speed camera. The observations were used to describe various boiling modes on the GEWA-TTM surface. The addition of hexane to pure R123 caused a simultaneous reduction in the bubble diameter and increase in the site density. The increase in site density enhanced the boiling despite the reduction in bubble size. Presumably, the site density enhancement was caused by a layer enriched in hexane at the heat transfer surface. The addition of hexane to R123 also improved natural convection. The natural convection was influenced by the greater thermal conductivity of the excess layer which may have contained 55% mass hexane.

Kedzierski, M. A.; Kim, M. S.

Single-Phase Heat Transfer and Pressure Drop Characteristics of an Integral-Spine Fin Within an Annulus.

National Institute of Standards and Technology, Gaithersburg, MD

Journal of Enhanced Heat Transfer, Vol. 3, No. 3, 201-210, 1996.

annulus; enhanced heat transfer; heat transfer; spine-fin; friction; water; ethylene glycol; prandtl number

The laminar, single-phase heat transfer and friction characteristics of a porcupine-like surface (integral-spine-fin) within an annulus are presented. The heat-transfer coefficient was determined using a modified version of the Wilson Plot method on a 3 m test section. Three fluids were investigated: (1) water, (2) 34% ethylene glycol/water mixture, and (3) 40% ethylene glycol/water mixture. These fluids produced a significant variation in the Prandtl number so that its exponential dependence could be determined. The annulus Reynolds numbers were varied from 100 to 1400 to obtain the Reynolds number exponent. An empirical correlation for the Nusselt number that accounts for the development of the thermal boundary layer is presented. An empirical correlation for the fanning friction factor is also provided. It is shown that the spines enhance the heat transfer through additional surface area and fluid mixing.

Kennedy, I. M.; Yam, C.; Rapp, D. C.; Santoro, R.; Tsang, W.

Modeling and Measurements of Soot and Species in a Laminar Diffusion Flame.

California Univ., Davis

Pennsylvania State Univ., University Park

Combustion and Flame, Vol. 107, No. 4, 368-382, December 1996.

soot; laminar flames; diffusion flames; ethene; chemical reactions; equations

A model of laminar, soot-laden ethene diffusion flames has been developed and compared with measurements in nonsooting and sooting flames. Concentrations of stable gas-phase species were measured with mass spectrometry; laser-induced fluorescence was used to measure the OH concentrations. A system of elementary reactions was used to describe the gas-phase chemistry. The model incorporated a simple description of the growth of soot which assumed that acetylene was the only growth species. Soot formation was coupled with the flame chemistry via the loss of acetylene and OH on soot and the production of CO during soot oxidation. The model predicted most of the gas-phase species quite well, with the exception of OH. The loadings of soot in the flames were reporduced adequately, although less success was achieved in predicting the transition from nonsooting to sooting conditions. Details concerning the products of soot oxidation by OH were found to be important with regard to the flame chemistry. The inclusion of soot in the flame model had a significant impact on the predicted structure of the flame as seen in changes to the formation and destruction rates of OH on the fuel side of the flame. The rate of OH reaction with soot in the midregion of the flame was small compared with the rate of reaction of OH with CO. However, the two rates became comparable in the soot burnout zone.

Kim, B. S.; Domanski, P. A.
Intracycle Evaporative Cooling in a Vapor Compression Cycle.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5873; 25 p. September 1996.
Available from National Technical Information Service
PB97-116107

cooling; air conditioning; building technology; coefficient of performance; heat pump; refrigeration; zeotropic mixtures

The temperature glide of zeotropic mixtures during phase change provides the opportunity to limit throttling losses of the refrigeration cycle by intracycle evaporative cooling of the refrigerant leaving the condenser. Intracycle evaporative cooling is similar to the use of a liquid-line/suction-line heat exchanger with the difference that a two-phase low-pressure refrigerant, instead of superheated vapor, is used to subcool the high-pressure liquid leaving the condenser. Intracycle evaporative cooling was evaluated by a semi-theoretical simulation model and experimentally in an instrumented laboratory heat pump at the cooling mode operating condition typical for a water-to-water residential heat pump. The capacity, coefficient of performance (COP), pressures, and temperature profiles of refrigerant and heat-transfer fluid in the heat exchangers are reported. The laboratory measured improvement of the COP was 4.0% for R32/152a, 3.6% for R407C, and 1.8% for R23/152a.

Kim, B. S.; Domanski, P. A.
Limiting Throttling Losses by Intracycle Evaporative Cooling.
LG Electronics, Changwon City, Korea
National Institute of Standards and Technology, Gaithersburg, MD
KSME-JSME Thermal Engineering Conference, Third (3rd). October 20-23, 1996, Kyongju, Korea, 1996.

cooling; evaporative cooling; simulations; test facilities; refrigeration

The temperature glide of zeotropic mixtures during phase change provides the opportunity to limit throttling losses of the refrigerant leaving the condenser. The difference between the intracycle evaporative cooling and the liquid-line/suction-line heat exchanger, instead of superheated vapor, is that a two-phase low-pressure refrigerant is used to subcool the high-pressure liquid leaving the condenser. The merits of the intracycle evaporative cooling were evaluated by a semi-theoretical simulation model and in the NIST's Small Breadboard Heat Pump at the cooling mode operating condition typical for a water-to-water residential heat pump. The capacity, coefficient of performance (COP), pressures, and temperature profiles of refrigerant and heat-transfer fluid in the heat exchangers are reported. The laboratory measured improvement of the COP was 4.0% for R32/152a(50/50),3.6% for R407C, and 1.8% for R23/152a(20/80).

Kim, M. S.; Morrison, G.; Mulroy, W. J.; Didion, D. A.
Study to Determine the Existence of An Azeotropic R-22 "Drop-In" Substitute.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5784; 48 p. March 1996.
Available from National Technical Information Service
PB96-167812

azeotropic refrigerant mixtures; air conditioning; heat pump; alternative refrigerants; refrigeration; working fluids; HFC-134a; propane; cyclopropane; isobutane

The reduction in chlorofluorocarbon(CFC) and hydrochlorofluorocarbon(HCFC) production and the scheduled phase-out of these ozone depleting refrigerants requires the development and determination of environmentally safe refrigerants for use in heat pumps, water chillers, air conditioners and refrigerators. Azeotropic mixtures are attractive as alternative refrigerants because they behave very nearly as pure materials. A simple correlation scheme that allows one to judge whether or not an azeotrope is likely in a binary refrigerant mixture is discussed. This paper presents laboratory and computer simulation

evaluation of two of the azeotropic refrigerant mixtures which were identified, HFC-134a(1,1,1,2-tetrafluoroethane)with R-290 (Propane) and HFC-134a with R-600a (isobutane), in a generic heat pump apparatus. A third azeotropic mixture, HFC-134a with R-C290 (Cyclopropane) is examined by computer simulation only. The performance characteristics of these azeotropes were compared with pure CFC-12, HFC-134a, HCFC-22, and R-290 at high temperature cooling and heating conditions. Use of liquid-line/suction-line heat exchange was evaluated.

Kline, S. W.; Palmer, M. E.
Application Protocol 227 Validation Report Version 1.0.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5875; 86 p. August 1996.
Available from National Technical Information Service
PB97-132104

pipes; heating; ventilation; air conditioning; validation

Part 227 of ISO 10303, "Plant Spatial Configuration," specifies an application protocol (AP) for the exchange of spatial configuration information of process plants. This includes shape characteristics, spatial arrangement characteristics, and design and fabrication information for piping system components, and functional and stream information for piping and HVAC (heating, ventilating, and air conditioning) systems. Also included are shape and spatial arrangement characteristics of other related plant systems that impact the design and layout of piping systems. This report describes the plan for validating AP 227 and the results of various review and validation tasks. This report has individual sections describing the validation of the major components of the Application Protocol: scope and requirements evaluation, application reference model validation, integrated resources interpretation, application interpreted model validation, and conformance requirements evaluation. The validation process has been completed in parallel with the development of the application protocol. Thus, the completion of sections of this document has been dependent on whether the analogous part of the AP 227 document had been completed. This is, therefore, a living document that will be updated periodically as the AP 227 document is updated. This version of the validation report is based on the Committee Draft (CD) version of AP 227.

Kline, S. W.; Palmer, M. E.; Appel, N.; Gilbert, M.
Group 1 for the Process Engineering Data STEP Application Protocol.
National Institute of Standards and Technology, Gaithersburg, MD
Product Data Integration Technology, Inc., Long Beach, CA
NISTIR 5909; 655 p. October 1996.
Available from National Technical Information Service
PB97-116073

application protocol; process engineering data; process design; process specifications; equipment

Part 231 of ISO 10303, "Process Engineering Data: Process Design and Process Specifications of Major Equipment," specifies an application protocol (AP) for the exchange of process engineering and conceptual design information for process plants. This information forms the conceptual basis for the specification, selection, and operation of process plant equipment over the plant life cycle. This AP supports continuous and batch processes, process simulations, stream data, unit operations, conceptual design requirements for major process equipment, and conceptual process control strategies. This document specifies the scope and information requirements for AP 231 and provides the Application Activity Model (AAM) and Application Reference Model (ARM) for the AP. The document follows the format and clause numbering scheme prescribed for this type of International Organization for Standardization (ISO) standard. The clauses and annexes contained in this document are those required by ISO for Group 1 review and comments.

Kline, S. W.; Palmer, M. E.; Burkett, W.; Craig, D.; Skeels, J. A.
Plant Spatial Configuration Application Protocol. Version 1.0. Volume 2.
National Institute of Standards and Technology, Gaithersburg, MD
Product Data Integration Technology, Inc., Long Beach, CA
NISTIR 5812; 292 p. December 1995.

application protocol; building technology; electrical system; HVAC system; instrumentation and control systems; piping system; process plant; spatial configuration; structural system

Part 227 of ISO 10303, "Plant Spatial Configuration", specifies an application protocol (AP) for the exchange of spatial confiruration information of process plants. This includes shape characteristics, spatial arrangement characteristics, and design and fabrication information for piping system components, and functional and stream information for piping and HVAC (heating, ventilating, and air conditioning) systems. Also included are shape and spatial arrangement characteristics of other related plant systems that impact the design and layout of piping systems. This document specifies the scope and information requirements for AP 227 and provides the Application Activity Model (AAM), Application Reference Model (ARM), and Application Interpreted Model (AIM) for the AP. The document follows the format and clause numbering scheme prescribed for this type of International Organization for Standardization (ISO) standard. The clauses and annexes contained in this document are those required by ISO for Committee Draft (CD) review and balloting.

Kline, S. W.; Palmer, M. E.; Burkett, W.; Skeels, J. A.
Group 1 for the Plant Spatial Configuration STEP Application Protocol.
National Institute of Standards and Technology, Gaithersburg, MD
Product Data Integration Technology, Long Beach, CA
NISTIR 5675; 198 p. June 1995.
Available from National Technical Information Service
PB96-165402

building structure; application protocol; explicit shape representation

Part 227 of ISO 10303, "Plant Spatial Configuration", specifies an application protocol (AP) for the exchange of spatial configuration information of process plants. This include shape characteristics, spatial arrangement characteristics, and design and fabrication information for piping system components, and functional and stream information for piping and HVAC (heating, ventilating, and air conditioning) systems. Also included are shape and spatial arrangement characteristics of other related plant systems that impact the design and layout of piping systems. This document specifies the scope and information requirements for AP 227 and provides the Application Activity Model (AIM) and Application Reference Model (ARM) for the AP. The document follows the format and clause numbering scheme prescribed for this type of International Organization for Standardization (ISO) standard. The clauses and annexes contained in this document are those required by ISO for Group 1 qualification. Additional clauses and annexes will be added to the AP during the completion of the standard.

Klote, J. H.; Braun, E.
Water Leakage of Elevator Doors With Application to Building Fire Suppression.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5925; 18 p. December 1996.
Available from National Technical Information Service
PB97-132013

doors; elevators (lifts); fire suppression; fire fighting; water; leakage; sprinklers; fire hoses

In recent years, considerable interest has been expressed in improving elevator use during fires (ASME 1991 and 1995, Klote et al. 1992). Water exposure due to sprinklers and fire hoses is a major concern of the fire service with the use of elevators during fires, because of the effect that water can have on electrical and electronic elevator components. The National Elevator Industry Incorporated (NEII) and NIST are engaged in a cooperative research project to study water flow issues of elevator

use during fires. Because of the wide range of designs of elevator components, studying the impact of water on specific elevator components would have limited applicability. Thus the project focuses on water flow rates into elevator hoistways (elevator shafts) and the flow paths in the hoistways with the intent of providing information that might be useful to industry in dealing with this issue. This paper describes a series of laboratory tests to: (1) determine typical flow rates of water through elevator doors, (2) observe water leakage patterns, (3) evaluate the performance of modified door gibs and brackets intended to reduce or redirect water leakage, and (4) evaluate a test enclosure concept for possible field testing.

Klote, J. H.; Forney, G. P.; Davis, W. D.; Bukowski, R. W.
Simulating the Effects of HVAC Induced Air Flow From Slot Diffusers on Detector Response.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5908; 79 p. December 1996.
Available from National Technical Information Service
PB97-132393

heating; ventilation; air conditioning; fire models; smoke detectors

Rapid activation of fire protection systems in response to a growing fire is one of the important factors required to provide for life safety and property protection. Airflow due to the heating, ventilating and air conditioning (HVAC) system can significantly modify the flow of smoke along the ceiling and must be taken into consideration when a particular system is designed. At present, the standards used to guide the design of systems contain very little quantitative information concerning the impact of airflow produced by HVAC systems. This project is part of a multi year, International Fire Detection Research Project sponsored by the National Fire Protection Research Foundation (NFPFR), and it describes the results of a series of numerical simulations of smoke movement in response to HVAC flows resulting from slot diffusers, slot returns and rectangular returns. The computer model calculated activation times throughout the fire driven flow field.

Kostreva, M. M.
Sensitivity Analysis for Mathematical Modeling of Fires in Residential Buildings.
Clemson Univ., SC
NIST-GCR-95-683; 14 p. February 1996.
Available from National Technical Information Service
PB96-154968

residential buildings; sensitivity analysis; mathematical models; finite difference theory; fire models; zone models

The underlying equations used in the fire models HAZARDI and CONRAD2 are examined to establish a prototype method for sensitivity analysis applied to currently available zone fire models. Generic differential equations are derived which can supplement existing equations in fire models to estimate the time-varying sensitivity of model outputs. The implications on the validity of the solutions obtained and on the computing resources necessary to obtain such sensitivity information is discussed. The results of the proposed analytical approach is compared with estimates from finite difference analyses for the CONRAD2 model. These finite difference methods, while more computing intensive, provide more believable results than the analytical approaches examined.

L

Lawson, J. R.
Fire Fighter's Protective Clothing and Thermal Environments of Structural Fire Fighting.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5804; 26 p. August 1996.
Available from National Technical Information Service

fire fighters; protective clothing; structures; environments; heat transfer; burns (injuries); thermal insulation; fire load; building technology; flashover; fire data

Fire fighter's protective clothing is designed to perform several functions. Of these, protection from heat and flame is one of the most important. Today's fire fighter protective clothing designs are based on years of field experience and research studies which addressed structural fires. Much of this work has concentrated on the fire environment where a fire fighter suddenly becomes enveloped in flames. This exposure generally results in serious life threatening injuries and sometimes death. Little appears to have been done to address the conditions where most burn injuries occur, outside of the flaming envelope. This paper attempts to define the general thermal environment at locations where fire fighters stage and begin their attack on a fire. A great deal of research has been done to evaluate structural fires as they relate to building design, materials and contents. Only small elements of these data have been used in evaluating the thermal environment around fire fighters during normal attack situations. Results from early and recent studies clearly demonstrate the severity of thermal environments at fire attack staging areas. The flow of hot gases from a doorway or through a window may be well above 400 DGC (752 DGF) and may extend tens of meters down a corridor or across an adjoining room ceiling. Thermal radiation from a room's open doorway or window may reach levels which will cause burn injuries to exposed skin and cause charring or ignition of protective clothing fabrics which result in burn injuries to protected skin. Surface temperatures of solids within this staging zone may easily exceed 100 DGC (212 DGF), and touching these surfaces without protection could result in a sudden burn injury. A brief scenario is presented which serves as an example of how a fire fighter could receive second degree burns while attacking a fire from outside of the flaming envelope.

Lebon, L.; Oger, L.; Leblond, J.; Hulin, J. P.; Martys, N.; Schwartz, L. M.
Pulsed Gradient NMR Measurements and Numerical Simulation of Flow Velocity Distribution in Sphere Packings.
Labo PMMH-ESPCI, Paris, France
National Institute of Standards and Technology, Gaithersburg, MD
Schlumberger Doll Research Center, Ridgefield, CT
Physics of Fluids, Vol. 8, No. 2, 293-301, February 1996.

sphere packings; velocity distribution; porous media; water; experiments

The displacement of water molecules associated with the flow of water inside a nonconsolidated packing of 800 mm OD glass spheres has been measured by a pulsed gradient NMR technique. Using a stimulated spin-echo sequence, mean displacements of up to 300 mm corresponding to measurement times of up to 200 ms can be analyzed. The measurement can be quantitatively calibrated using the pure molecular self-diffusion of water at zero flow conditions. For molecular displacements much smaller than the pore size, the distribution of the flow velocity component along the mean flow direction is determined at Reynolds numbers high enough so that longitudinal molecular diffusion is negligible. An exponential decay of the probability distribution of the displacements is observed at large distances. The results are very similar to those obtained by numerical solution of the Stokes equation in random sphere packings. At longer displacement distances, a secondary peak of the displacement distribution is observed. It is interpreted as the first step toward the transition toward classical dispersion at displacements much larger than the pore size. The influence of molecular diffusion and of the heterogeneities of the magnetic permeability also are discussed.

Lederer, M. A.; diMarzo, M. A.; Tartarini, P.
Flooding Criterion for Evaporative Cooling on Horizontal Semi Infinite Solids.
Maryland Univ., College Park
Universita di Bologna, Italy
NIST-GCR-96-687; Paper 17; June 1996.
Available from National Technical Information Service
PB96-202304
American Society of Mechanical Engineers (ASME). National Heat Transfer Conference. ASME 31st Proceedings. Volume 4: Interfacial Phenomena; Boiling Heat Transfer; Thermal Hydraulics for Advanced Nuclear Reactions. HTD-Vol. 326. August 3-6, 1996, Houston, TX, American Society of Mechanical Engineers, New York, NY, White, L.; Singer, R. M.; Peterson, F.; Cheung, F. B., Editors, 213-217 pp, 1996.

water sprays; evaporative cooling; solids; flooding; formulation; sprays; equations; droplets

The evaporative cooling of a sparse spray impacting on a hot solid is investigated to determine the limiting condition associated with the liquid flooding of the solid surface. The flooding condition is identified when the evaporation rate is insufficient to remove the amount of water being deposited on the surface. The flooding criteria is derived as a function of the initial single droplet volume prior to deposition, the Evaporation-Recovery Cycle (ERC) and the area of influence, which describes the region of the solid surface associated with a single droplet cooling effect. These last two quantities, the ERC and the area of influence, are evaluated by integrating previously obtained theoretical and experimental information with selected experimental data obtained in this study. The flooding criteria, while semi-empirical in its derivation, can be generalized to all non-porous solids under a variety of conditions. The spray is sparse and the water droplets are considered of uniform size. Extension to a spray with non-uniform droplet distribution is not considered here.

Lee, K. Y.; Cha, D. J.; Hamins, A.; Puri, I. R.
Heat Release Mechanisms in Inhibited Laminar Counterflow Flames.
University of Illinois, Chicago
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 104, No. 1/2, 27-40, 1996.

combustion; hazardous materials; waste disposal; laminar flames; heat release; methodology; inhibitors; flame stability; radiative heat loss

Due to the participation of inhibitors in flame chemistry, it is difficult to concurrently characterize the complex interaction between their cooling action, and the chemical inhibition (which decrease temperature), and their contribution of heat release (which increases temperature). Investigations involving chemical inhibitors have to contend with three interacting phenomena, i.e., (1) the cooling action due to the specific heat of the species; (2) the heat release due to their burning; and (3) inhibition associated with scavenging of critical radical species. This study investigated the effect of chloromethane (a chemical inhibitor due to its halogenation) on the heat release in methane-air nonpremixed flames. For comparison, the effect on the heat release due to the purely thermal action of nitrogen (which does not exhibit chemical inhibition or heat release effects) was also investigated. The flames were experimentally and numerically studied in a counterflow configuration, and the heat release was calculated from simulations involving detailed chemistry. When inert suppressants were added to the oxidizer stream of a nonpremixed flame, the global heat release decreased. Chloromethane addition to the fuel stream, however, increased the heat release. Whereas addition of nitrogen narrowed the heat release region, chloromethane addition to the oxidizer altered the flame stoichiometry, such that the heat release profiles were markedly different. Halogenated compounds can influence radiative thermal losses from flames through changes in flame structure that effect the temperature and soot concentration. Therefore, a small Schmidt-Boelter type gauge was used to measure the radiative flux through a cylindrical control volume surrounding the flame, and the total radiation emitted from the flame was calculated by integrating the emitted flux. The results show that as nitrogen was added to the methane-air base flame, the radiative heat loss fraction decreased slightly. When chloromethane was added to the oxidizer stream, the radiative heat loss fraction increased substantially (=40%). Values of the radiative heat loss fraction remained relatively small (=2.3%) for all of the flames studied.

Lee, W. Y.; Park, C.; House, J. M.; Kelly, G. E.
Fault Diagnosis of an Air-Handling Unit Using Artificial Neural Networks.
Korea Institute of Energy Research, Taejon, South Korea
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions, Vol. 102, No. 1, 540-549, 1996.

air handling unit; neutral network; fault diagnosis; pattern recognition

The objective of this study is to describe the application of artificial neural networks to the problem of fault diagnosis in an air-handling unit. Initially, residuals of system variables that can be used to quantify the dominant symptoms of fault modes of operation are selected. Idealized steady-state patterns of the residuals are then defined for each fault mode of operation. The steady-state relationship between the dominant symptoms and the faults is learned by an artificial neural network using the backpropagation algorithm. The trained neural network is applied to experimental data for various faults and successfully identifies each fault.

Lee, W. Y.; Park, C.; Kelly, G. E.
Fault Detection in an Air-Handling Unit Using Residual and Recursive Parameter Identification Methods.
Korea Institute of Energy Research, Taejon, South Korea
National Institute of Standards and Technology, Gaithersburg, MD
ASHRAE Transactions, Vol. 102, No. 1, 528-539, 1996.

air handling unit; fault detection; residual method; system identification method

A scheme for detecting faults in an air-handling unit using residual and parameter identification methods is presented. Faults can be detected by comparing the normal or expected operating condition data with the abnormal, measured data using residuals. Faults can also be detected by examining unmeasurable parameter changes in a model of a controlled system using a system parameter identification technique. In this study, autoregressive moving average with exogenous input (ARMAX) and autoregressive with exogenous input (ARX) models with both single-input/single-output (SISO) and multi-input/single-output (MISO) structures are examined. Model parameters are determined using the Kalman filter recursive identification method. This approach is tested using experimental data from a laboratory's variable-air-volume (VAV) air-handling unit operated with and without faults.

Lentati, A. M.; Chelliah, H. K.
Dynamics of Water Droplets in a Counterflow Field and Its Effect on Flame Extinction.
University of Virginia, Charlottesville
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 3-4 pp, 1996.
Available from National Technical Information Service

fire research; fire science; water; droplets; flame extinguishment

Efficient suppression of flames by condensed-phase agents (e.g., dry powder, water, etc.) requires a basic understanding of the rate-controlling physical, thermal and chemical processes. A steady, laminar, non-premixed flame, established within the mixing layer of a counterflow of methane and air, is used here to numerically determine the rate controlling processes associated with flame extinction by fine water droplets. Although experiments are planned to validate the model, only the numerical results with water droplets introduced with the air stream are reported here.

Lewis, J. A.; Galler, M. A.; Bentz, D. P.
Computer Simulations of Binder Removal From 2-D and 3-D Model Particulate Bodies.
University of Illinois, Urbana
National Institute of Standards and Technology, Gaithersburg, MD
Journal of the American Ceramic Society, Vol. 79, No. 5, 1377-1388, 1996.

binder removal; building technology; capillary transport; computer models; microstructure; particulate body; simulation

A series of computer simulations were developed to investigate the removal of multicomponent, thermoplastic binders from two- and three-dimensional model particulate bodies. Monosized particles with varying diameters were randomly placed in such systems, and all unoccupied pixels were assigned to the binder phase at ratios of 1:9, 1:2, or 1:1 plasticizer (volatile) to polymeric (nonvolatile) species. Simulations were carried out under isothermal conditions to study the influence of liquid-phase transport processes, i.e., plasticizer diffusion in the binder-filled pore network and capillary-driven redistribution of the binder phase, on plasticizer removal rates. Plasticizer diffusion was modeled by a random-walk algorithm, and nonplanar pore development arising from capillary-driven binder redistribution was modeled by an invasion percolation algorithm. For comparison, simulations were also carried out on systems in which binder redistribution was not permitted. In such cases, pore development was modeled as an advancing or nonadvancing planar front. Visualization of transport phenomena on a microscopic scale has provided the first quantitative assessment of plasticizer concentration profiles, C(t) and C(z), and binder-vapor interfacial development during removal. Removal rates were significantly enhanced when capillary-driven binder redistribution was assumed, and they depended strongly on initial plasticizer content under those conditions.

Linteris, G. T.; Reinelt, D.
Inhibition of Flames by Condensed-Phase Agents.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 477-486 pp, 1996.

fire safety; fire suppression; chemical inhibition; flame chemistry; flame models; flame retardants; particulates; premixed flames; diffusion flames

The ban on the production of the fire suppressant CF3Br has created a need for replacement agents. Obvious alternatives are other halogenated hydrocarbons, and much research has recently been devoted to understanding their relative performance and inhibition mechanisms. However, an agent with all of the desirable properties of CF3Br is proving difficult to find. Consequently, the National Institute of Standards and Technology (NIST) is undertaking research to identify new chemical suppressants and understand the mechanisms of inhibition of known agents, particularly those which have shown strong inhibiting effects.

Linteris, G. T.; Truett, L.
Inhibition of Premixed Methane-Air Flames by Fluoromethanes.
National Institute of Standards and Technology, Gaithersburg, MD
Air Force Materials Lab., Wright-Patterson AFB, OH
Combustion and Flame, Vol. 105, No. 1/2, 15-27, April 1996.

chemical inhibition; flame chemistry; flame models; flame retardants; flame speed

This paper presents the first calculations and measurements of the burning velocity of premixed hydrocarbon flames inhibited by the three one-carbon fluorinated species CH2F2, CF3H, and CF4. The chemistry of these agents is expected to be similar to that of some agents that may be used as replacements for CF3Br, so that studying their behavior in methane flames provides

an important first step towards understanding the suppression mechanism of hydrocarbon fires by fluorinated compounds. The burning velocity of premixed methane-air flames stabilized on a Mache-Hebra nozzle burner is determined using the total area method from a schlieren image of the flame. The inhibitors are tested over a range of concentration and fuel-air equivalence ratio. The measured burning rate reduction caused by addition of the inhibitor is compared with that predicted by numerical solution of the species and energy conservation equations employing a detailed chemical kinetic mechanism recently developed at the National Institute of Standards and Technology (NIST). Even in this first test of the kinetic mechanism on inhibited hydrocarbon flames, the numerically predicted burning velocity reductions for methane-air flames with values of equivalence ratio of 0.9, 1.0, and 1.1 and inhibitor mole fractions in the unburned gases up to 0.08, are in excellent agreement for CH2F2 and CF4 and within 35% for CF3H. The numerical results indicate that the agents CF3H and CH2F2 are totally consumed in the flame and the burning velocity is reduced primarily by a reduction in the H-atom concentration through reactions leading to HF formation. In contrast, only about 10% of the CF4 is consumed in the main reaction zone and it reduces the burning velocity primarily by lowering the final temperature of the burned gases.

Lippiatt, B. C.; Norris, G. A.
Selecting Environmentally and Economically Balanced Building Materials.
National Institute of Standards and Technology, Gaithersburg, MD
Public Technology, Inc. and U.S. Green Building Council. Selecting Environmentally and Economically Balanced Building Materials. Reprinted as Chapter 2 of Sustainable Building Technology Manual: Green Building Design, Construction, and Operations. Economics and Environment. Part 1. Chapter 2, Gottfried, D., Editors, 1.13-1.19 pp, June 1996.

building technology; building materials; environmental performance; green buildings; impact assessment; impact valuation; inventory analysis; life cycle assessment; life cycle costing; multi-attribute decisions

The building community wants to move toward the use of building materials with improved environmental performance at little or no increase in cost. A methodology for evaluating the environmental and economic performance of building materials is described. This methodology is being implemented in decision support software that will access a publicly available database of environmental and economic performance data for building materials. The software will assist designers and manufacturers in comparing the environmental/economic performance of alternative building materials. The National Institute of Standards and Technology is collaborating with the U.S. Environmental Protection Agency in this effort.

M

Madrzykowski, D.
Office Work Station Heat Release Rate Study: Full Scale vs. Bench Scale.
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 47-55 pp, 1996.

fire safety; fire behavior; furniture; heat release rate; cone calorimeters; experiments; large scale fire tests; heat flux

The National Institute of Standards and Technology (NIST) has conducted a study with office work stations to examine their heat release rates and to determine if the peak heat release rate for a work station can be predicted accurately from cone calorimeter results. Fifteen full scale fire experiments were conducted. Three types of work station panel construction and three work station configurations were examined. Preliminary results for the most common panel construction, fabric over fiberglass batting with a 6 mm thick hardboard core, are presented here. A method utilizing the peak heat release rate from the cone calorimeter experiments has been used successfully to predict peak heat release rates for the most common construction work station. This study is part of the Office Building Fire Research Program being conducted at NIST's Building and Fire Research Laboratory under the sponsorship of the U.S. General Services Administration.

Marshall, H. E.
Sensitivity Analysis.
National Institute of Standards and Technology, Gaithersburg, MD
Engineering Handbook. Chapter 187, CRC Press, Inc., Boca Raton, FL, Dorf, R. C., Editor(s), 1962-1967 p., 1996.

sensitivity analysis; heating equipment; commercial buildings

Sensitivity analysis measures the impact on project outcomes of changing one or more key input values about which there is uncertainty. For example, a pessimistic, expected, and optimistic value might be chosen for an uncertain variable. Then an analysis could be performed to see how the outcome changes as each of the three chosen values is considered in turn, with other things held the same. In engineering economics, sensitivity analysis measures the economic impact resulting from alternative values of uncertain variables that affect the economics of the project. When computing measures of project worth, for example, sensitivity analysis shows just how sensitive the economic payoff is to uncertain values of a critical input, such as the discount rate or project maintenance costs expected to be incurred over the project's study period. Sensitivity analysis reveals how profitable or unprofitable the project might be if input values to the analysis turn out to be different from what is assumed in a single-answer approach to measuring project worth.

Marshall, H. E.; Petersen, S. R.
Life-Cycle Costing.
National Institute of Standards and Technology, Gaithersburg, MD
Mechanical Estimating Guidebook. Chapter 27. Sixth (6th) Edition, McGraw-Hill, Inc., New York, NY, Gladstone, J.; Humphreys, K. K., Editor(s)(s), 407-417 p., 1995.

life cycle; building construction; costs; air conditioning; sensitivity analysis; mechanical equipment; service life

Contractors and design professionals need practical methods and guidelines for evaluating the economic performance of mechanical systems in buildings. Life-cycle cost (LCC) snalysis is one method for making such evaluations. LCC analysis is used to evaluate alternative systems which compete on the basis of coast. Thus only candidate systems which satisfy all performance requirements (e.g., code, safety, comfort, and reliability requirements) can be legitimately compared using the LCC method. The system alternative with the lowest LCC over the project study period is the most cost-effective choice.

Martin, J. W.; Persily, A. K.; Guenther, F. R.; Nguyen, T.; Liggett, W. S., Jr.; Byrd, W. E.; Oakley, L.
Materials-Science Based Approach to Phenol Emissions From a Flooring Material in an Office Building.
National Institute of Standards and Technology, Gaithersburg, MD
Indoor Air Quality and Climate, 7th International Conference. Proceedings. Indoor Air '96. Volume 2. July 21-26, 1996, Nagoya, Japan, 109-114 pp, 1996.
phenol; emissions; air quality; flooring; epoxy; office buildings; sampling; thermogravimetric analysis
After several years of indoor air quality complaints in an office building, it was hypothesized that phenol emissions from an epoxy floor-leveling material were the source of the complaints. A materials-science based study was performed to ascertain whether phenol, or any other volatile organic compound, was being emitted from the floor-leveling material. The chemical composition and physical properties of the leveling material were determined using a variety of analytical procedures typical of a materials-science based approach. It was concluded that the floor-leveling material contained phenol, and that the measured concentrations ranged from 0.25% to 0.52% of the material's mass. Several strategies for mitigating the phenol emissions were considered, and it was concluded that the most practical strategy would be to remove the floor-leveling material from the building and replace it with a portland cement-based material.

Martin, P. M.
Two CD-ROM Publications: FASTLite and BFRL Publications, 1995.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Technology, Vol. 32, No. 4, 372-373, November/December 1996.
fire research
The Fire Safety Engineering Division (FSED) of the Building and Fire Research Laboratory/National Institute of Standards and Technology (BFRL/NIST) has introduced two new CD-ROM publications this year, FASTLite and BFRL Publications 1995, and a new Web site, "Fire on the Web."

Martin, P. M.; Jason, N. H.
BFRL Publications, 1995. Volume 1 and Volume 2.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 900; May 1996.
Available from authors, NIST, Building 224, Room A252,
Gaithersburg, MD 20899 Fax: (1) + 975-4052
fire research; building technology; elevators (lifts); fire models; fire tests; halons; mass fires; smoke detection; smoke control; soot; sprinklers; fire research; building construction; building design; cements; concretes; earthquakes; disasters; weather effects; wind velocity; building codes
This CD-ROM set contains publications in full text by the National Institute of Standards and Technology/Buildingand Fire Research Laboratory (NIST/BFRL) staff and related fire research grant reports. Only items published during 1995 are included.

Martys, N. S.; Chen, H.
Simulation of Multicomponent Fluids in Complex Three-Dimensional Geometries by the Lattice Boltzmann Method.
National Institute of Standards and Technology, Gaithersburg, MD
Exa Corp., Cambridge, MA
Physical Review E, Vol. 53, No. 1, 743-750, January 1996.

lattice boltzmann method; simulation; fluids; fluid flow; porous media

We describe an implementation of the recently proposed lattice Boltzmann based model of Shan and Chen to simulate multicomponent flow in complex three-dimensional geometries such as porous media. The above method allows for the direct incorporation of fluid-fluid and fluid-solid interactions as well as an applied external force. As a test of this method, we obtained Poiseuille flow for the case of a single fluid driven by a constant body force and obtained results consistent with Laplace's law for the case of two immiscible fluids. The displacement of one fluid by another in a porous media was then modeled. The relative permeability for different wetting fluid saturations of a microtomography-generatedimage of sandstone was calculated and compared favorably with experiment. In addition, we show that a first-order phase transition, in three dimensions, may be obtained by this lattice Boltzman method, demonstrating the potential for modeling phase transitions and multiphase flow in porous media.

McAvoy, T. J.; Milke, J.; Kunt, T. A.
Using Multivariate Statistical Methods to Detect Fires.
Maryland Univ., College Park
Fire Technology, Vol. 32, No. 1, 6-24, January/February 1996.

fire detection systems; fire detectors; false alarms; sensors; experiments; fire tests; detection time

Fire detectors must accurately detect fires, but they should not respond to false alarms. Contemporary smoke detectors sometimes cannot discriminate between smoke and odor sources. These detectors can also be slow in respondingto smoldering fire sources. In this paper, a statistical approach for detecting fires based on fusing sensor signals from multiple sensors is presented. The multivariate statistical approach, called principal componentanalysis, is used to compress the sensor information down to a small number of variables that can be interpreted more easily than the raw sensor signals themselves. Experimental results presented here show that the proposed approach is more accurate than a conventional smoke alarm, particularly for early detection of smoldering fires. However, this new approach does not overcome the problem of false alarms. In spite of this current limitation, the method discussed holds great promise for future fire detection.

McGrath, J. E.; Ghassemi, H.; Riley, D.; Wan, I. Y.; Bhatnagar, A.; Kashiwagi, T.
Synthesis and Characterization of New Thermopolastic Fire Resistant Materials.
Virginia Polytechnic Institute and State Univ., Blacksburg
National Institute of Standards and Technology, Gaithersburg, MD
Plastics: Racing Into the Future. SPE Annual Technical Conference and Exhibits, 54th. ANTEC '96. Proceedings, 3043-3048 pp, 1996.

fire resistant materials; thermoplastics

Thermally stable high performance polyimides, poly(aryleneether), and poly(arylenesulfide) systems containing aryl phosphine oxide comonomers in controlled concentrations have been prepared and characterized. In general, tough thermoplastic materials have been produced that show significant char yield in air, which increase with the concentration of aryl phosphineoxide. Thus, they are considered candidates for fire safe thermoplastic materials. Preliminary cone calorimetry measurements have been conducted on lower performance aliphatic polyamides, which indicate that, indeed, the heat of combustion is reduced. Additional characterization studies are in progress and will be discussed at the meeting.

McGrattan, K. B.; Baum, H. R.; Deal, S. P.
Numerical Simulation of Rapid Combustion in an Underground Enclosure.
National Institute of Standards and Technology, Gaithersburg, MD
Tomes, Van Rickley and Associaties, Carlsbad, CA
NISTIR 5809; 16 p. April 1996.
Available from National Technical Information Service
PB96-183132

combustion; enclosures; fluid dynamics; high temperature; tests; accelerants; zone models; fire models; field models

The scenario of interest is a two second firing of a rocket engine in an underground enclosure intended to mimic the effect of burning a high temperature accelerant (HTA). Because of the unusual nature of the problem, at least in the context of typical fire scenarios, two types of numerical models have been applied to the problem. The first, a zone model, divides each room in the enclosure into one or two control volumes, and the transport of mass and energy from the burn room is estimated from the basic conservation laws. The second model, a field model designed for relatively low Mach number flows, solves the conservation equations of mass, momentum and energy discretized over hundreds of thousands of cells. The first approach has the advantage of providing a fast, robust description of the overall thermodynamic quantities of interest. The second approach provides a much more detailed description of the temporal and spatial evolution of these quantities. The energy release for the two second firing of the rocket is enormous. In all, 245 kg (540 lb) of solid fuel is consumed in two seconds. The total energy released is given as 1093 cal/g (4575 kJ/kg). Of this, it is estimated that about half is lost to the walls or converted to kinetic energy. The remaining energy creates a tremendous pressure and temperature rise throughout the facility. Both the zone model (CFAST2.0) and the field model (NIST Large Eddy Simulation) predict that the pressure in the enclosure after the 2 s firing will rise about 1 atmosphere, and the temperature about 1500 C. Both models simulate one minute following ignition, by which time the pressure in the entire enclosure has returned to atmospheric and the temperature to several hundred degrees over ambient, depending on location. There is little convective motion by this time, and the temperature decrease is largely dependent on the absorption of heat by the walls.

McGrattan, K. B.; Kashiwagi, T.; Baum, H. R.; Olson, S. L.
Effects of Ignition and Wind on the Transition to Flame Spread in a Microgravity Environment.
National Institute of Standards and Technology, Gaithersburg, MD
NASA Lewis Research Center, Cleveland, OH
Combustion and Flame, Vol. 106, No. 4, 377-391, September 1996.

flame spread; microgravity; spacecraft; ignition; wind effects

A two-dimensional, time-dependent model is developed describing ignition and the subsequent transition to flame spread over a thermally thin cellulosic sheet heated by external radiation in a microgravity environment. The effects of a slow external wind (0-5 cm/s), and of the flux distribution of the external radiation on the transition are studied mainly in an atmosphere of 30% oxygen concentration. The ignition is initiated along the width of a sample strip, giving rise initially to two flame fronts spreading in opposite directions. The calculated results are compared with data obtained in the 2.2-s drop tower. Both experimental and calculated results show that with a slow, imposed wind, the upstream flame front (opposed mode) is stronger and slightly faster than the quiescent counterpart due to a greater supply of oxygen. However, the downstream flame front (concurrent mode) tends to die during the transition period. For all calculated cases studied in this work using the selected kinetic constants for the global one-step gas phase reaction, the downstream flame front dies out in oxygen concentrations up to 50% and wind velocity up to 5 cm/s. This is caused by the "oxygen shadow" cast by the upstream flame. The ignition delay time depends mainly on the peak flux of external radiation, whereas the transition time to steady state flame spread depends mainly on the broadness of the flux distribution. The broader the radiative flux distribution, the greater the transient flame spread rate due to the preheating of the sample ahead of the flame front by the external radiation and thus the greater the delay to steady state flame spread.

McGrattan, K. B.; Trelles, J. J.; Baum, H. R.; Rehm, R. G.
Smoke Plume Trajectory Over Two-Dimensional Terrain.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 65-66 pp, 1996.
Available from National Technical Information Service

fire research; fire science; smoke plumes; crude oil; water; in situ combustion; oil spills

Under the sponsorship of the U.S. Minerals Management Service and the Alaska Department of Environmental Conservation, the National Institute of Standards and Technology has conducted a series of large outdoor burns of crude oil on water to assess the feasibility of using in situ burning as an oil spill remediation tool. In conjunction with these experiments, a numerical (ALOFT - A Large Outdoor Fire plume Trajectory) model has been developed to predict the downwind concentration of smoke particulate and other combustion products. The numerical model has been carefully compared with results from field experiments, and the results are very favorable.

McKnight, M. E.
Brief Guide to Internet Resources for Coatings-Related Regulations and Associated-Coatings Information.
National Institute of Standards and Technology, Gaithersburg, MD
Steel Structures Painting Council (SSPC). Technologies for a Diverse Industry. SSPC 1996 Seminars. Proceedings. SSPC 96-08. November 17-21, 1996, Charlotte, NC, 1996.

coatings; Internet; paints; World Wide Web; URL

The Internet is a ready source of current information relevant to the coatings industry. Hundreds of World Wide Web sites on the Internet have information on regulations and other coatings-related topics. The objectives of this paper are to introduce inexperienced Internet users to the kinds of regulatory and other coatings-related information available on the Internet and to provide some key Web sites that are useful in initiating searches and obtaining information.

McKnight, M. E.
Protective Coatings Research: A Look Ahead.
National Institute of Standards and Technology, Gaithersburg, MD
Steel Structures Painting Council (SSPC). Technologies for a Diverse Industry. SSPC 1996 Seminars. Proceedings. SSPC 96-08. November 17-21, 1996, Charlotte, NC, 9-12 pp, 1996.

coatings; durability; service life; exposure; material properties; methodology

Coatings research has provided a technical basis for changes in coating materials brought about by the development and availability of new raw materials; users' expectations for more durable and easier to apply coatings; issuance of new government regulations involving volatile organic compounds (VOC) and toxic material content limits; and marketing concerns. Further, research results have provided useful information for making improved decisions in related areas, including lead-based paint removal, overcoating systems for lead-containing paint films, worker and environmental protection, and disposal of lead-containing paint debris.

Meacham, B. J.
Concepts of a Performance-Based System for the United States.
Society of Fire Protection Engineers, Boston, MA
Institut de Securite. Fire Safety Conference on Performance Based Concepts. Proceedings. October 15-17, 1996, Zurich, Switzerland, 14/1-9 pp, 1996.

fire safety; fire codes; building codes; standards; regulations; evaluation

A number of countries around the world are using or developing performance-based regulations. To provide a forum for discussion on the transition to a performance-based regulatory system in the United States, the Society of Fire Protection Engineers convened a focus group of representatives from the United States' building and fire communities. A conceptual model, terminology and definitions were distributed to the focus group participants as the basis for discussion, and a two-day meeting was convened to facilitate discussion and gain consensus on the future direction for the United States. The conceptual model and the focus group consensus are presented.

Meeks, C. B.; Brannigan, V.
Performance Based Codes: Economic Efficiency and Distribution Equity.
University of Georgia, Athens
Maryland Univ., College Park
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 573-580 pp, 1996.

fire safety; codes; decision making; costs; failure; fire retardant treatments; plywood; risk analysis

Performance based codes are justified based on their economic efficiency. Economic efficiency can only be achieved if decision makers make the optimum trade off between cost of injuries and injury avoidance activities. Private decision makers may be tempted to achieve cost savings by shifting cost to other parties not involved in the decision process. These "externalities" represent a significant source of market failure. Market failures may be addressed by restructing the marketplace, regulating private behavior, or public provision of the service itself. All three of these responses have a place in performance based codes. Other market failures can exist and performance based codes must be implemented in a way to increase, not decrease the efficiency of the market. Efficiency is not the only social goal. Societies also concern themselves with the problem of distributional equity. Distributional equity describes who bears the burdens of specific social policy choices. Performance based codes may raise significant distributional equity problems, especially if the person bearing the burden of the fire risk is unable to participate in the regulatory decision process e.g., homeowners. A short case study of fire retardant treated plywood illustrates the economic problems involved in inadequate performance based analysis.

Milke, J. A.; Caro, T. C.
Evaluation of Survey Procedures for Determining Occupant Load Factors in Contemporary Office Buildings.
Maryland Univ., College Park
NIST-GCR-96-698; 24 p. September 1996.
Available from National Technical Information Service
PB97-116222

office buildings; chairs; computers; evaluation; fuel loads; furniture; interior furnishings; office furniture; surveys

The development of survey methods for determining the occupant load in office buildings (business occupancies) is described. Considerations involved in formulating the survey methods are presented. The type of data to be collected and data collection techniques are discussed. The two survey methods utilized to collect the population counts within contemporary office buildings are a building walk-through and a telephone survey. Occupant load data obtained from the survey methods applied in 23 office buildings located in the Washington, DC area are presented. Data are presented on the magnitude and distribution of the loads. The building data is sorted according to the following groups: open plan office designs versus well-compartmented office designs, and government (federal and county) versus privator sector tenants. Statistical summaries of the data are

presented. Buildings that are primarily composed of open plan office designs are found to have greater occupant load factors than buildings composed of well-compartmented office designs. County government office buildings are found to be slightly greater occupant load factors than federal government buildings. Federal government buildings have lesser occupant load factors than private office buildings. The mean occupant load factor found in the study for all buildings is 248 ft2/person. The telephone survey technique yielded a slightly greater occupant load factor than did the building walk-through technique. However, because the two survey approaches yielded relatively similar results, both are considered to be acceptable in assessing office building occupant loads. The telephone survey requires substantially less time and effort to complete, but is dependent on building management's knowledge of the occupancy characteristics. The walk-through approch required reviewing building drawings and an on-site walk-through of the building.

Milke, J. A.; Hill, S. M.
Full-Scale Room Fire Experiments Conducted at the University of Maryland.
Maryland Univ., College Park
NIST-GCR-96-703; 32 p. October 1996.
Available from National Technical Information Service
PB97-116081

fire markings; fire research; full scale burn; ignition; bedrooms; experiments

Two full size furnished bedrooms were burned, June 5 and June 6, at the University of Maryland Fire and Rescue Institute Facilities. These burns were performed for two cooperating agencies: The Alcohol, Tobacco and Firearms Agency of the Treasury Department, who used them as part of their Certified Fire Investigator training, and the Building and Fire Research Laboratory of NIST, who used them for forensic research. It was intended that these two burns be identical, to see if close analysis of the results would find differences. There were differences, possibly due to small differences in the inflow of ventilation air. In both cases, ignition was caused by burning newspaper on an upholstered chair. This report describes the test arrangement and instrumented results.

Milke, J. A.; McAvoy, T. J.
Neural Networks for Smart Fire Detection. Final Report.
Maryland Univ., College Park
NIST-GCR-96-699; 317 p. December 1996.
Available from National Technical Information Service
PB97-138267

fire detection; experiments; data analysis

Research was conducted using multiple sensors with an algorithm to detect fires more quickly than currently available smoke detectors while also decreasing the susceptibility to unnecessary alarms. The effort involved the production of signatures from three types of sources: flaming fires, non-flaming fires and non-fire, nuisance sources, followed by analysis to recognize signature patterns for the three types of sources. The first phase of research consisted of establishing the feasibility of distinguishing between signatures from fire and non-fire sources using a small-scale apparatus. The second phase consisted of introducing the signatures in a 12 ft. square room with a height of 8 ft. Measurements included CO, CO2, and O2 concentrations, presence of oxidizable gases, light obscuration and temperature. The signatures measured could be associated with the three types of sources. Using a multivariate statistical analysis, the response time of a prototype detector was appreciably less than that of commercially available detectors, with a significant reduction in unnecessary alarm susceptibility. In the third phase, pairs of sources were provided simultaneously to determine if a nuisance source could mask the signature from a fire source and if two nuisance sources provide a signature similar to that from a fire. Results indicate that the ratio of the CO to CO2 concentrations is representative of flaming fire sources and to a limited extent for non-flaming fire sources, independent of the presence of a nuisance source.

N

Nguyen, T.; Byrd, W. E.
In Situ Measurement of Metal Ions at the Polymer/Substrate Interface Using Infrared-Active Sensors.
National Institute of Standards and Technology, Gaithersburg, MD
Adhesion Society Meeting. February 1996, 453-455 pp, 1996.
metal ions; sensors; polymer/substrate interface; ft-ir; in situ measurements

The transport of metal ions along the polymer/steel interface is believed to be the controlling factor in the cathodic delamination of polymer-coated steel exposed to electrolytes. In situ measurement of metal ions at the polymer/substrate interface would provide critical information for understanding and modeling the delamination rate of this material. A number of techniques can be used for measuring metal ions on solid surface or in solution. However, most of these techniques are not suitable for in situ investigation at the buried polymer/substrate interface. Infrared (IR) spectroscopy in the internal reflection mode on a suitable substrate is attractive for such study because it probes the interface from the substrate side and can be used at ambient conditions.

Nguyen, T.; Byrd, W. E.; Bentz, D. P.; Lin, C.
In Situ Measurement of Water at the Organic Coating/Substrate Interface.
National Institute of Standards and Technology, Gaithersburg, MD
Xiamen Univ., China
Progress in Organic Coatings, Vol. 27, 181-193, 1996.
organic coating; substrate interface; water measurement

In situ and quantitative information on the water layer at the organic coating/substrate interface is crucial for understanding and preventing the failure of organic coating systems. A technique, based on a two-layer model derived rigorously from internal reflection theory, has been developed for measuring in situ the thickness and amount of the water layer at the organic coating/substrate interface. The technique gives new insight into the processes by which water degrades the coating/substrate bonds. In this technique, a transparent or an opaque organic coating of sufficient thickness is applied to an internal reflection element (IRE) with or without a thin metallic film, which is used as the substrate. A water chamber is attached to the organic-coated specimen. After adding water to the chanber, Fourier transform infrared-multiple internal reflection (FTIR-MIR) spectra are taken automatically at specified time intervals without disturbing the specimens or the instrument. Water uptake in the coating and FTIR-MIR spectra of water on the coating-free substrate are also used for the analysis. Examples of clear and pigmented coatings on untreated and treated substrate surfaces are given to demonstrate the technique. Results of water accumulation at the coating/iron interface with and without applied electrical potentials are given. In addition to measuring water at the coating/substrate interface, the technique provides a means for studying the transport of water through a coating adhered to a substrate. Information on water at the interface and its transport properties through coatings applied to a substrate is valuable for interpreting corrosion, blistering and delamination of organic coating systems, and for developing models for use in predicting the service lives of protective coatings.

Nguyen, T.; Byrd, W. E.; Bentz, D. P.; Seiler, J. F., Jr.
Development of a Method for Measuring Water-Stripping Resistance of Asphalt/Siliceous Aggregate Mixtures.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5865; 49 p. July 1996.
Available from National Technical Information Service
PB96-202296

building technology; adhesions; aggregates; asphalt; bonding strength; FT-IR; interface; spectroscopy; stripping; water

The main objective of this project was to develop a nondestructive, sensitive, spectroscopic method for measuring water stripping resistance at the molecular level of asphalt/siliceous aggregate mixtures exposed to water. The study consisted of three phases. Phase 1 involved the development of a technique based on Fourier transform infrared spectroscopy in the multiple internal reflection mode to quantify the water layer at the interface between an asphalt and a siliceous aggregate. Phase 2 was to develop a technique to measure the adhesion loss of an asphalt/aggregate system exposed to water environment. And Phase 3 aimed to relate the quantity of the interfacial water layer with the adhesion loss data. This final report summarizes the research in those three areas. In addition, the report also presents the results on the use of the spectroscopic technique for evaluating the effectiveness of different antistripping agents for asphalts. And finally, based on the interfacial water information, the mechanisms of stripping of an asphalt from a siliceous aggregate and of the transport of water from the environment to the asphalt/aggregate interface are presented.

Nguyen, T.; Hubbard, J. B.; Pommersheim, J. M.
Unified Model for the Degradation of Organic Coatings on Steel in a Neutral Electrolyte.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
Journal of Coatings Technology, Vol. 68, No. 855, 45-56, April 1996.

coatings; corrosion; degradation; electrolyte; quantitative

A unified model is presented for the degradation of an organic protective coating on a steel substrate exposed to a neutral electrolytic environment. This model is based on theoretical and experimental studies from our laboratory and on current understanding of the degradation process. The assumptions of the model are based on the concept that degradation of a coating/steel system occurs following the transport of ions through conductive pathways, which are presumably formed by an attack by water in the "hydrophylic", low-molecular-weight/low-cross-linked regions, followed by the connections of these regions. Models for the blistering and delamination resulting from corrosion processes are based on the diffusion of cations along the coating/steel interface from the detects to cathodic sites under the coatings. The resulting equations are solved to predict ion fluxes and concentration profiels along the interface and within blisters. Model variables include blister size, distance between blister and defect, ion diffusivity, and potential gradients. Experimental results agree well with theoretical predictions.

Nguyen, T.; Martin, J. W.
Modes and Mechanisms of Degradation of Epoxy-Coated Reinforcing Steel in a Marine Environment.
National Institute of Standards and Technology, Gaithersburg, MD
Durability of Building Materials and Components 7th. Volume 1. Chapter 51. 1996, E&FN Spon, London, England, Sjostrom, C., Editor, 491-502 pp, 1996.

coatings; concrete solution; corrosion; degradation; marine; rebars; steels

Blasted-steel panels were coated with two commercial powder epoxy coatings at two thicknessess. half of the coated panels were scribed; the other half remained free of defects. The panels were immersed in a saturated calcium hydroxide aqueous solution containing 3.5% sodium chloride maintained at either 35 or 50DGC. Degradation was quantified by infrared thermography, wet adhesion test, and microscopic and analytical techniques. Unscribed panels exhibited only water-induced adhesion loss, but scribed specimens degraded by anodic blistering and cathodic disbondment, in addition to water-induced adhesion loss. Anodic blistering was attributed to localized crevice corrosion under coating followed by blistering via an osmotic pressure mechanism. Cathodic disbondment was caused by the alkalinity of the corrosion products at the cathodic sites. Water-induced adhesion loss was due to the presence of multiple layers of water at the coating/steel interface.

Nguyen, T.; McKnight, M. E.; Byrd, W. E.
Development of a Test Method for Leaching of Lead From Lead-Based Paints Through Encapsulants.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5783; 39 p. February 1996.
Available from National Technical Information Service
PB96-154984

coatings; encapsulant; diffusion; lead; leaching; paints; test methods

Lead in paint has been associated with lead poisoning in children. The use of polymeric encapsulants is a potential abatement method for controlling the exposure to lead from lead-based paints. The objective of this study was to provide a technical basis for a standard test method to measure the transport of lead through polymeric encapsulants. In developing this method, the following variables were investigated: lead pigment type and concentration in the lead-based film, chemical type and pH of leaching solutions, and encapsulant resins. The lead-containing films were prepared using a linseed oil binder. The encapsulants were water-borne epoxy and acrylic products and an oil-based alkyd paint. An experimental setup consisting of a cylinder attached to lead-based film, with and without an encapsulant, applied to a poly(methyl methacrylate) (PMMA) substrate was found suitable for a lead leaching test. A pH controlled system was required and found convenient for controlling the pH of the leaching solutions. Little (<5%) lead was leached from a linseed-oil film containing either lead chromate or lead carbonate pigment immersed in inoganic acids or bases in the pH range between 2 and 12, suggesting that little lead would be expected to leach from a lead-based painted wll when the wall comes into contact with weak inorganic acids, or ammonia-based cleaning solutions. Because sufficient lead must be leached from the paint to measure the transport properties of encapsulants, additional leaching agents were investigated. Among the chemical compounds studied, acetic acid was the most efficient lead leaching agent. A pH 2, 3.5 mol/L acetic acid in water leached nearly 70% lead from a lead carbonate-containing film within 5 hours; this is about 70 times greater than amount of lead leached after 100 hours in a nitric solution of the same pH. Consequently a leaching solution containing 3.5 moles acetic acid in 1 liter of water was chosen. For lead-based films under an encapsulant, an induction period exists before lead begins to leach out of the films. After the induction time, a substantial amount of lead leached from the lead-based films under epoxy and acrylic encapsulants and the alkyd paint. The rate in the water-born encapsulants were higher than that of the oil-based alkyd paint. FTIR in the internal reflection mode provided a good method to follow the conversion of acetic acid to lead acetate, and these data were used for determining the diffusion coefficient of lead acetate in a lead-based film. The diffusion coefficient of lead acetate formed from a vinegar solution in a lead-based film was found to be in the same range as other organic acetates, 10-10 cm2/s. The diffusion coefficients of 100% acetic acid in lead-based linseed-oil films, encapsulants, and alkyd paint were measured using a video/computer image analysis procedure; the values are in the 10-9 cm2/s to 10-11 cm2/s range. Acetic acid was found to be a good candidate for leaching lead from a lead-based film with and without an encapsulant covering it.

Notarianni, K. A.; Gott, J. E.; Davis, W. D.; Lowe, D. L.; Laramee, S.
Analysis of High Bay Hangar Facilities for Detector Sensitivity and Placement.
National Institute of Standards and Technology, Gaithersburg, MD
Naval Facilities Engineering Command, Alexandria, VA
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 487-496 pp, 1996.

fire safety; fire suppression; sprinklers; sprinkler systems; fire protection; pool fires; smoke detection; smoke movement; experiments; burning rate; heat release rate

This study was conducted to investigate the response of various fire detectors and automatic sprinklers in high bay aircraft hangars. Laboratory and full-scale experiments as well as computer modeling were conducted to better understand the movement of heat and products of combustion in high bay spaces. Temperature distribution across the ceiling was measured along with the response of various types of fire protection devices as a function of fire size, fuel type, and ventilation

conditions. Key findings are presented relating to detector spacing, threshold fire sizes, sprinkler type and temperature ratings, burn rates, heat release rates, and the effect of draft curtains.

Nyden, M. R.
Applications of Molecular Dynamics to the Study of Thermal Degradation in Polymers.
Department of Energy, Pittsburg, PA
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 131-132 pp, 1996.
Available from National Technical Information Service
fire research; fire science; thermal degradation; fire resistant materials; flammability
The flammability of polymeric materials is a major concern which impacts public safety and limits their use in buildings, ships, aircraft and clothing. Unfortunately, the traditional "trail and error" approach to the design of fire resistant materials is not cost effective. This realization has provided an impetus for the research conducted in this laboratory which has focused on using molecular dynamics modeling to identify factors which alter the condensed phase thermal degradation chemistries of polymers in ways which effect a reduction in their flammability.

Nyden, M. R.; Vallikul, P.; Sivathanu, Y. R.
Tomographic Reconstruction of the Moments of Local Probability Density Functions in Turbulent Flow Fields.
National Institute of Standards and Technology, Gaithersburg, MD
Purdue Univ., West Lafayette, IN
Journal of Quantitative Spectroscopy Radiative Transfer, Vol. 55, No. 3, 345-356, 1996.
probability; transmission; turbulence; algorithms; turbulent flow; flow fields; equations
An algorithm for the tomographic reconstruction of the individual moments of the probaility density functions describing the local transmittance of radiation through a turbulent flow field is advanced. The new method, which is based on Fourier inversion, is applicable to asymmetric (as well as, to axisymmetric) flows. The validity of the method is examined by comparing reconstructed moments of the local probability functions in a buoyant propene/air flame and an ethene/air jet flame to the corresponding values obtained from optical probe measurements.

O

Ohlemiller, T. J.; Shields, J. R.
Prevention of Surface Fire Growth on Structural Composites.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 137-138 pp, 1996.
Available from National Technical Information Service
fire research; fire science; composite materials; fire growth; structures; coatings
Fiber-reinforced polymer composites are very attractive materials for a variety of infrastructure uses. For example, they are capable of replacing concrete and steel in such applications as bridge decks or even entire bridge structures and they are

expected to offer significant life-cycle cost advantages in applications of this type. However, such large volume applications call for commodity polymer resins like polyester or vinyl ester whose flammability can be a substantial concern. The traditional way in which to deal with this flammability issue has been to incorporate bromine-based flame retardants into the resin. Another alternative is the use of phenolic resins; these strongly charring polymers are inherently less flammable than the ester resins.

Ostadan, F.; Deng, N.; Arango, I.
Energy-Based Method for Liquefaction Potential Evaluation. Phase 1. Feasibility Study.
Bechtel Corp., San Francisco, CA
NIST-GCR-96-701; 272 p. August 1996.
Available from National Technical Information Service
PB96-214747

building technology; liquefaction; strain energy; earthquakes; ground response; cyclic testing; laboratory measurements; ground motion; pore pressure

This report presents the results of the first phase of a three-phase study on development and application of the energy-based method for prediction of the liquefaction potential of sandy soils. The formulation of the method is based on the convolution of the basic elements from both the "stress" and "strain" approaches and is very flexible in incorporating the special characteristics of ground motion such as the near-field effects. The feasibility phase consists of the tasks: 1) to collect and synthesize laboratory data; 2) to perform ground response analyses at the Wildlife Site, which suffered a massive ground liquefaction failure during the Superstition Hills Earthquake; and finally 3) to compare and to assess the differences between the field and the laboratory data. Even though the scope of the feasibility study did not permit cyclic testing of the soil samples from the Wildlife Site, the correlation of the field response data and the applicable laboratory data are strong. The results of this phase suggest that development of an energy-based method to evaluate liquefaction potential is feasible.

P

Paige, H. L.; Berry, R. J.; Schwartz, M.; Marshall, P.; Burgess, D. R. F.; Nyden, M. R.
Ab Initio Calculations and Kinetic Modeling of Halon and Halon Replacements.
WL/MLBT, Wright-Patterson AFB, OH
University of North Texas, Denton
National Institute of Standards and Technology, Gaithersburg, MD
Halon Options Technical Working Conference. May 7-9, 1996, Albuquerque, New Mexico, 1-12 pp, 1996.

halon replacements; halons; kinetics

The mode of action of the chemical-acting flame suppression agents such as the halons is generally, though not universally, accepted. The details of the several reactions involved in chemical suppression have been studied by many groups using experimental and computational techniques. In this paper we report on the calculation of formation enthalpies for a number of halocrabons used, or proposed for use, in flame suppression. Additional calculations have been completed on the radical species and transition states that are important in describing key reactions of flame suppressants. These data are being used to calculate kinetic rate constants that will be used to improve the detailed description of flame extinguishment. Comparisons of computational and experimental results are given.

Perera, D. Y.; Nguyen, T.
Hygroscopic Stress and Failure of Coating/Metal Systems.
Coatings Research Inst., Limelette, Belgium
National Institute of Standards and Technology, Gaithersburg, MD
Paint, Varnish, Ink and Adhesive Industry. Eurocoat Congress, 1996. September 1996, Italy, 1-17 pp, 1996.

coatings; stress; hygroscopic; corrosion; degradation

Stress development in various types of organic coatings was determined under wet conditions. The values of hygroscopic stress obtained are correlated with the results of other tests such as electrochemical impedance spectroscopy, water uptake, adhesion, thermal analysis. The role of the hygroscopic stress in organic coating degradation is discussed. It is suggested that this stress participates in formation and/or enlargement of pathways in the coating, which enables the transport of the electrolyte to the metallic substrate provoking its corrosion. The knowledge of its destructive action will enhance our understanding of the controlling factors in corrosion of coated metals.

Persily, A. K.
Carbon Monoxide Dispersion in Residential Buildings: Literature Review and Technical Analysis.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5906; 74 p. October 1996.
Available from National Technical Information Service

carbon monoxide; exposure; indoor air quality; literature reviews; residential buildings; ventilation

Carbon monoxide (CO) detectors are being used increasingly in residential buildings to warn occupants about CO concentrations that could potentially cause acute health effects. While the use of CO detectors can decrease the likelihood of exposure to such CO levels, questions exist concerning the installation of these devices in residential buildings, primarily with regards to the location and number of detectors. Efforts to develop installation guidance and standards have been faced with these question of location, and the availability of technical information to support the development of installation recommendations has been questioned. As the first task of a project to analyze the distribution of CO in residential buildings as it relates to the installation of CO detectors, a literature review and technical analysis was conducted to assess information on CO dispersion in residential buildings that could support the development of guidance on detector installation. The review covered a number of issues including CO concentration measurements in residential buildings, sources of indoor CO, mixing within and between rooms, tracer gas techniques for assessing building airflow, and computer models of air movement and contaminant dispersal in buildings. The material obtained in the literature review is discussed, and a technical analysis of the issues related to CO dispersion in residential buildings is presented.

Persily, A. K.
Issues in the Field Measurement of VOC Emission Rates.
National Institute of Standards and Technology, Gaithersburg, MD
Indoor Air Quality and Climate, 7th International Conference. Proceedings. Indoor Air '96. Volume 2. July 21-28, 1996, Nagoya, Japan, 49-54 pp, 1996.

indoor air quality; volatile organic compounds; emissions; sources; measurement; computer simulation; equations

The measurement of VOC emission rates in the field can be valuable in indoor air quality research, in evaluations of the indoor air quality impacts of design, and in the diagnosis of indoor air quality problems. Current approaches to measuring these emission rates have been based on a single-zone mass balance and have employed a number of simplifying assumptions. This paper reviews the mass balance theory employed in field measurements of VOC emission rates. Some concerns associated with these measurements are discussed including the assumption of equilibrium VOC concentrations and the neglect of adsorption

and desorption of VOC on building surfaces. Computer simulations are described that provide an order-of-magnitude assessment of the impacts of these issues.

Persily, A. K.
Relationship Between Indoor Air Quality and Carbon Dioxide.
National Institute of Standards and Technology, Gaithersburg, MD
Indoor Air Quality and Climate, 7th International Conference. Proceedings. Indoor Air '96. Volume 2. July 21-26, 1996, Nagoya, Japan, 961-966 pp, 1996.

carbon dioxide; air quality; indoor air quality; ventilation; odors

In some situations, measurements of indoor CO2 concentrations can be used to assess indoor air quality and ventilation. However, oversimplified descriptions of measurement procedures based on CO2 have been presented, and there have been many cases where indoor CO2 concentrations have been misinterpreted. This paper describes the relationship of indoor CO2 concentrations to building air quality and ventilation, with a focus on how CO2 can be used to evaluate air quality and ventilation performance. While CO2 concentrations do not provide a comprehensive indication of indoor air quality, they can be used to assess the acceptability of a space in terms of human body odor. Also, under some circumstances CO2 can be used to evaluate building ventilation, specifically air change rates and percent outdoor air intake.

Petersen, S. R.
BLCC: The NIST "Building Life-Cycle Cost" Program, Version 4.3 User's Guide and Reference Manual.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5185-3; 33 p. October 1995.
Available from National Technical Information Service
PB96-199229

air pollution; emissions; manuals; computer programs; life cycle cost; energy conservation; carbon dioxide; surlfur dioxide; nitrous oxide

The NIST Building Life-Cycle Cost (BLCC) computer program provides economic analysis of proposed capital investments that are expected to reduce long-term operating costs of buildings or building systems/components. It is especially useful for evaluating the costs and benefits of energy conservation projects in buildings. Two or more alternative designs can be evaluated to determine which has the lowest life-cycle cost and therefore is most economical in the long run. Economic measures, including net savings, savings-to-investment ratio, adjusted internal rate of return, and years to payback can be calculated for any design alternative relative to the designated base case. BLCC can be used for evaluating federal (including Department of Defense), state, and local government projects as well as projects in the private sector. It complies with ASTM standards related to building economics as well as Federal Energy Management Program (FEMP) and Office of Management and Budget (OMB) Circular A-94 guidelines for economic analysis of federal building projects. While BLCC is primarily intended for the economic evaluation of building systems, it can be applied to a wide range of project investments which are intended primarily to reduce future operating-related costs. The "Quick Input" program (QI) included with BLCC can be used to set up multiple project alternatives for LCC analysis in a single input file. While the range of input data is somewhat limited, QI is sufficient for many simple LCC problems and provides a new link to the DOE ASEAM 5.0 energy calculation program. QI can also be used to generate input data files for BLCC when more comprehensive analysis is required. BLCC and QI are designed to run on an IBM-PC or compatible microcomputer with approximately 640K of random access memory and a hard disk or disk drive capble of handling high-density diskettes. BLCC and QI are updated annually (on October 1) to include the current DOE energy price projections and federal discount rates.

Petersen, S. R.
EMISS: A Program for Estimating Local Air Pollution Emission Factors Related to Energy Use in Buildings. User's Guide and Reference Manual.
National Institute of Standards and Technology, Gaithersburg, MD

NISTIR 5704; 33 p. October 1995.
Available from National Technical Information Service
PB96-109566

air pollution; emissions; manuals; computer programs; life cycle cost; energy conservation; carbon dioxide; sulfur dioxide; nitrous oxide

EMISS is a computer program used to generate data files with regional or local air pollution emission factors for use with the NIST BLCC (Building Life-Cycle Cost) program. BLCC uses these emission factors to calculate air pollution emissions associated with energy use in buildings and reductions in those emissions attributable to energy conservation measures. Three types of emission factors are currently included in EMISS data files: carbon dioxide, sulfur dioxide, and nitrous oxide. Emission factors are specified separately for six different end-use energy types: electricity, distillate and residual fuel oil, natural gas, liquid petroleum gas (LPG), and coal. Emission factors for fossil fuels can be regionalized or localized by specifying the percentage of sulfur in the fuel, the heating content of the fuel, and the end-use combustion process at the building site. A data base with state-specific electricity emission factors and U.S. average sulfur content of fossil fuels provides default data for use in setting up a regional or local emission factors file. EMISS is intended for use on an IBM or compatible PC running under DOS.

Petersen, S. R.
Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis 1997. Annual Supplement to NIST Handbook 135 and NBS Special Publication 709.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 85-3273-11; 66 p. July 1996.
Available from National Technical Information Service
PB96-210745

life cycle cost; cost analysis; energy conservation; water conservation

This is the FY 1997 edition of energy price indices and discount factors for performing life-cycle cost analyses of energy and water conservation and renewable energy projects in federal facilities. It supports the federal life-cycle costing methodology by updating the energy price projections and discount factors that are described, explained, and illustrated in NIST Handbook 135 (HB 135, "Life-Cycle Costing Manual for the Federal Energy Management Program"). It supports private-sector life-cycle cost analysis by updating the energy price indices that are described, explained, and illustrated in NBS Special Publication 709 (SP 709). It also supports the Energy Conservation Mandatory Performance Standards for New Federal Residential Buildings (10 CFR 435) by providing a table of factors for updating appliance label values.

Petersen, S. R.
Energy Price Indices and Discount Factors for Life-Cycle Cost Analysis, 1996. Annual Supplement to NIST Handbook 135 and NBS Special Publication 709. Data for the Federal Methodology for Life-Cycle Cost Analysis, Title 10, CFR, Part 436, Subpart A; and for the Energy Conservation Mandatory Performance Standards for New Federal Residential Buildings, Title 10 CFR, part 435.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 85-3273-10; 66 p. October 1995.
Available from National Technical Information Service

costs; cost analysis; energy conservation; water conservation; methodology

This is the 1996 annual edition of energy price indices and discount factors for performing life-cycle cost analyses of energy and water conservation and renewable energy projects. It supports the federal life-cycle costing methodology by updating the energy price projections and discount factors that are described, explained, and illustrated in NIST Handbook 135 (HB 135). It supports private-sector life-cycle cost analysis by updating the energy price indices that are described, explained, and illustrated in NBS Special Publication 709 (SP 709). It also supports the Energy Conservation Mandatory Performance

Standards for New Federal Residential Buildings (10 CFR 435) by providing a table of factors for updating appliance label values.

Petersen, S. R.
Present Worth Factors for Life-Cycle Cost Studies in the Department of Defense (1996). Data for DoD Compliance With the Federal Methodology for Life-Cycle Cost Analysis, Title 10, CFR, Part 436, Subpart A, and OMB Circular A-94.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 4942-3; 60 p. October 1995.
Available from National Technical Information Service
PB96-106869

costs; construction; life cycle; maintenance

This document provided 47 tables of present worth factors to be used in computing the present worth of future costs (or cost reductions) in economic analyses of design decisions for projects in the DoD Military Construction Program. These factors are especially useful for the life-cycle cost analysis of investments in buildings or building systems which are intended to reduce future operating, maintenance, repair, replacement, and energy costs over the life of the facility. The tables include present worth factors for both one-time costs and annually recurring costs, based on the FEMP discount rate of 4.1% (FY 1996) for energy-related studies and on the OMB discount rate of 4.6% and 4.9% for short-term and long-term non-energy studies, respectively. Forecasts of future energy prices used in the calculation of present worth factors for energy costs were provided by the Energy Information Administration.

Phan, L. T.
Fire Performance of High-Strength Concrete: A Report of the State-of-the-Art.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5934; 115 p. December 1996.
Available from National Technical Information Service
PB97-132153

building technology; compressive strength; concretes; elastic modulus; explosive spalling; fire tests; high-strength concrete; test methods; thermal behavior; codes; temperature

A review is presented of experimental and analytical studies on the performance of concrete when exposed to short-term, rapid heating as in a fire. Emphasis is placed on concretes with high original compressive strengths, that is, high-strength concretes (HSC). The compiled test data revealed distinct difference in mechanical properties of HSC and normal strength concrete (NSC) in the range between room temperature and about 450 ○C. The differences decreased at temperature above 450 ○C. What is more important is that many test programs, but not all, reported that HSC experienced explosive spalling during the fire tests. The spalling is theorized to be caused by the buildup of pore pressure during heating. HSC is believed to be more susceptible to this pressure build up because of its low permeability compared with NSC. However, no explanations were found for why spalling did not occur in all HSC specimens. Analytical models for predicting the buildup of internal pressure during heating are also reviewed. The report also includes a comparison of test results with existing code provisions on the effects of fire on concrete strength. It is shown that the Eurocode provisions and the CEB design curves are more applicable to NSC than to HSC. In fact, these provisions are unsafe when compared with HSC test results. The review showed a lack of experimental data for lightweight HSC heated under a constant preload to simulate the stress conditions in HSC columns. The report concludes with an outline of a research plan to gain an understanding of the failure mechanisms in fire exposed HSC. The ultimate goal of the research is to develop tools for predicting the performance of HSC when exposed to fire.

Phan, L. T.; Lew, H. S.
Strengthening Methodology for Lightly Reinforced Concrete Frames.
National Institute of Standards and Technology, Gaithersburg, MD
Earthquake Engineering, 11th World Conference. Proceedings. Paper No. 1896. June 23-28, 1996, Acapulco, Mexico, Elsevier Science Ltd., 1-8 pp, 1996.

analytical; building technology; dynamic analysis; experimental; frames; hysteresis models; infilled walls; rehabilitation; reinforced concretes; seismic strengthening; system identification

To develop an analytical tool for assessing seismic performance of strengthened lightly reinforced concrete (LRC) frames, hysteresis failure models were developed and incorporated into computer program IDARC for dynamic analysis of LRC frames. The models were developed by, first, using the system identification techniques to characterize the load-deformation histories of LRC frame tests in terms of the stiffness degradation parameter alpha, the strength degradation parameter beta, and the pinching parameter gamma. Next, multi-variable regressions were performed to relate alpha, beta, gamma as functions of the specimen's material and geometric properties and reinforcement parameters. The empirical expressions resulting from these regression analyses are the hysteresis failure models. The models were validated against experimental results and used in a parametric study to evaluate the influence of certain variables to the behavior of infilled LRC frames. The variables included the thickness of infilled wall, the amount of reinforcement in infilled walls, and the area of anchors which connects the infilled wall to the frame. General design guidelines are proposed.

Phan, L. T.; Taylor, A. W.
State-of-the-Art Report on Seismic Design Requirements for Nonstructural Building Components.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5857; 73 p. June 1996.
Available from National Technical Information Service
PB96-193800

building technology; building codes; ceiling component; earthquakes; nonstructural component; nonstructural damage; seismic design requirement

Seismic design requirements for nonstructural building components of five major building codes, including the 1994 Uniform Building Code, the 1994 Standard Building Code, the 1994 NEHRP Recommended Provisions for Seismic Regulations for New Buildings, the New Zealand Building Code, and the Japanese Building Code, were reviewed in this study. Comparisons of codes reveal wide variation in seismic force and displacement requirements, both in terms of levels of stringency and levels of details. The difference in seismic force requirements between the most and least stringent codes can be more than five times. The study also found a lack of focused investigations, dedicated to mitigating seismic damage to nonstructural building components, even though widespread damage to nonstructural building components continues to be observed in recent earthquakes. Based on the findings of this review, areas of needed research were identified.

Pielert, J. H.; Baumert, C.; Green, M.
ASCE Standards on Structural Condition Assessment and Rehabilitation of Buildings.
National Institute of Standards and Technology, Gaithersburg, MD
Keast and Hood Co., Philadelphia, PA
Melvyn Green and Associates, Torrance, CA
American Society for Testing and Materials. Standards for Preservation and Rehabilitation. ASTM STP 1258. 1996, Kelley, S. J., Editor, 126-136 pp, 1996.

standards; preservation; rehabilitation; building technology; evaluation

The American Society of Civil Engineers (ASCE) Committee on Structural Condition Assessment and Rehabilitation of Buildings prepares standards in three areas: structural condition assessment, assessment of the building envelope, and assessment of buildings for seismic considerations. The first standard completed in ASCE 11-90 Standard Guideline for

Structural Condition assessment of Existing Buildings. Current work of the committee includes revising ASCE 11, drafting a standard on assessment of the building envelope, and conversion of various documents of the Federal Emergency Management Agency (FEMA) related to seismic evaluation of buildings to standards.

Pielert, J. H.; Spellerberg, P. A.
AASHTO Materials Reference Laboratory: Thirty Years of Service to the Transportation Community.
National Institute of Standards and Technology, Gaithersburg, MD
TR News, Vol. 183, 22-28, March/April 1996.

research facilities; transportation; construction materials; inspection

The AASHTO Materials Reference Laboratory (AMRL) is a research associate program located at the National Institute of Standards and Technology (NIST) under the sponsorship of the American Association of State Highway and Transportation Officials. AMRL and the Cement and Concrete Reference Laboratory (CCRL), which is sponsored by the American Society for Testing and Materials, make up the Construction Materials Reference Laboratories at the NIST Building and Fire Research Laboratory. The primary mission of these two programs is to improve the quality of testing in laboratories that test construction materials. AMRL is involved with materials used in transportation projects, including soils, aggregates, traffic and structural paints, metals, plastic pipe, asphalt binders, and bituminous materials and mixtures. CCRL conducts programs for cements, concrete, aggregates, pozzolans, and reinforcing steel. Both laboratories are outstanding examples of how federal and state governments and the private sector can cooperate to meet a common goal; improving the quality of constrcution in the United States.

Pitts, W. M.
Rayleigh Light Scattering for Concentration Measurements in Turbulent Flows.
National Institute of Standards and Technology, Gaithersburg, MD
National Aeronautics and Space Administration/Lewis Research Center. Rayleigh Scattering Diagnostics Workshop. Scientific and Technical Information Program. NASA Conference Publication 10186. July 25-26, 1995, Cleveland, OH, 69-87 pp, 1996.

light scattering; concentration measurements; concentration fluctuations; flow fields; flow measurements; line cameras; rayleigh light scattering; turbulent jets

Despite intensive research efforts over a number of years, an understanding of scalar mixing in turbulent flows remains elusive. An understanding is required because turbulent mixing has a pivotal role in a wide variety of natural and technologically important processes. As an example, the mixing and transport of pollutants in the atmosphere and bodies of water are often dependent on turbulent mixing processes. Turbulent mixing is also central to turbulent combustion which underlies most hydrocarbon energy utiliztion in modern socities as well as unwanted fire behavior. Development of models for combusting flows is crucial for more efficient utilization of limited hydrocarbon fuel resources, reduction in environmentally harmful pollutants, more efficient chemical processes, and for the prediction of hazard associated with unwanted fire. However, an understanding of scalar mixing is required before useful models of turbulent mixing and, ultimately, turbulent combustion can be developed.

Plumb, O. A.; Richards, R. F.
Development of an Economical Video Based Fire Detection and Location System.
Washington State Univ., Pullman
NIST-GCR-96-695; 73 p. July 1996.
Available from National Technical Information Service
PB96-193743

fire detection systems; cameras; fire protection; fire research; heat transfer;

industrial plants

A method of detecting, locating, and sizing accidental fires based on the solution of an inverse heat transfer problem is described and a prototype video fire detection system employing that method is presented. The inverse heat transfer problem to be solved is that of the convective heating of a compartment ceiling by the hot plume of combustion gases rising from an accidental fire. An inverse problem solution algorithm capable of determining the location and heat release rate of the fire employing transient temperatures at the ceiling of the compartment as data is developed. A prototype system based on the use of a video camera to monitor an array of temperature-sensitive, color-changing sensors and capable of supplying the transient temperature data needed by the inverse problem solution algorith is described. The limits on the accuracy of the inverse problem solution algorithm are demonstrated by exercising the algorithm, on transient temperature data from computer simulated compartment fires. The performance of the prototype video fire detection system is demonstrated by employing it to determine the location and heat release rate of a small flame source in a lab scale test enclosure.

Portier, R. W.; Peacock, R. D.; Reneke, P. A.
FASTLite: Engineering Tools for Estimating Fire Growth and Smoke Transport.
NIST SP 899; 1996.
Available from NIST, Building 224, Room B250, Gaithersburg, MD
20899 USA Fax: (1) + 301-975-4052

computer programs; fire growth; smoke transport

R

Raufaste, N. J., Jr.
NIST Building and Fire Research Laboratory Projects Summaries, 1996.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 838-10; 226 p. September 1996.
Available from National Technical Information Service
Available from Government Printing Office
PB97-121818
SN003-003-03428-2

building research; building technology; applied economics; fire safety; fire science; materials engineering; mechanical engineering; environmental engineering; structural engineering

Construction is one of the Nation's largest industries. In 1995, total construction amounted to about $755 billion which is 12 percent of U.S. GDP (new construction put in place amounted to about $527 billion and renovation contributed about $228 billion). U.S. construction accounts for more than six million jobs. More than 60% of the nation's wealth is invested in constructed facilities. This annual report, "Project Summaries 1996", presents BFRL's research during 1996. These summaries show how out products (performance prediction, measurement, and test methods) support the industries of construction achieving the National Construction Goals (NCGs). BFRL has focused its research in three principal thrusts: 1. High Performance Construction Materials and Systems; 2. Automation in construction and Constructed Facilities; 3. Loss Reduction. BFRL's research is in the areas of structural engineering, materials engineering, mechanical and environmental systems, fire safety and engineering, fire science, and applied economics.

Raufaste, N. J., Jr. Editor
U.S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U.S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 28th. May 14-17, 1996, Gaithersburg, MD, 638 pp, 1996.
National Institute of Standards and Technology, Gaithersburg, MD
NIST SP 904; August 1996.
Available from Government Printing Office
SN003-003-03424-0
Available from National Technical Information Service
PB97-104376

bridges (structures); building technology; concretes; design criteria; disaster reduction; earthquakes; geotechnical engineering; ground failures; lifelines; liquefaction; masonry; repair and retrofit; risk assessment; seismic; standards; storm surge; structural engineering; tsunamis

This publication is the proceedings of the 28th Joint Meeting of the U.S.-Japan Panel on Wind and Seismic Effects. The meeting was held at the National Institute of Standards and Technology Gaithersburg, Maryland during May 14-17, 1996. The proceedings include the program, list of members, panel resolutions, task committee reports, and 46 technical papers written for this joint meeting. The papers were presented under five themes: (1) Storm Surge and Tsunamis (2) Earthquake Engineering, (3) Joint Cooperative Research Program, (4) Wind Engineering, and (5) Summaries of Task Committee Workshop Reports (oral presentations only).

Reed, K. A.
Data Exchange Standards for Construction Automation.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5856; May 1996.
National Institute of Standards and Technology. NIST Construction Automation Program, Report No. 2. NIST Construction Automation Workshop. Proceedings. Chapter One: Topical Lectures. Paper 1.6. March 20-31, 1995, 43-49 pp, 1995.
Available from National Technical Information Service
PB96-202239

construction; technology transfer; computers; standards

My computer integrated construction group was created some ten years ago to address data exchange standards and other issues related to helping the construction industry apply computing and, in particular, to help the construction industry integrate its use of computers.

Ritchie, S. J.; Kashiwagi, T.
Experimental Measurements and Numerical Predictions of the Gasification of Finite Thickness Polymers.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 101-102 pp, 1996.
Available from National Technical Information Service

fire research; fire science; gasification; thickness; burning rate; cone calorimeters

During polymer combustion, there are two general processes that influence the burning rate of the material; the flame zone heat feedback to the polymer surface and the corresponding gasification rate of the polymer. The two processes are directly coupled. This study focuses on the condensed-phase processes which affect the gasification rate. Presented are the results of an experimental and numerical study into the influence of sample thickness and back surface boundary condition on the gasification rate of thermoplastic polymer materials under non-flaming conditions. Typically, the influence of thickness is ignored in theoretical developments because of the simplicity or convenience in assuming a semi-infinite material. However, in real applications of polymers, a semi-infinite analysis may be inappropriate.

Rossiter, W. J., Jr.; Vangel, M. G.; Embree, E. J.; Kraft, K. M.; Seiler, J. F., Jr.
Performance of Tape-Bonded Seams of EPDM Membranes: Comparison of the Peel Creep-Rupture Response of Tape-Bonded and Liquid-Adhesive Bonded Seams.
National Institute of Standards and Technology, Gaithersburg, MD
NIST BSS 175; 67 p. May 1996.
Available from National Technical Information Service
PB96-183249
Available from Government Printing Office
SN003-003-03411-8

adhesive tapes; adhesive testing; bonding; building technology; creep-rupture; EPDM; microscopy; roofing; seams; time-to-failure

A study was conducted to compare the creep-rupture response (i.e., time-to-failure of TTF) of tape-bonded and liquid-adhesive-bonded seams of EPDM (ethylene-propylene-diene terpolymer) roofing membranes. Two commercial tape systems (i.e., tape and primer) and one liquid adhesive were applied to well-cleaned EPDM rubber. The creep-rupture experiments were conducted at 23 DGC (73 DGF) and 40% to 45% relative humidity under peel loads ranging from 3.1 N to 24.9 N (0.7 lbf to 5.6 lfb). For each adhesive system, the data were found to be fitted well by the model: ln(mean TTF)=b0 + b1 DT Load + b2 exp(b3 DT Load). A comparison of the fitted curves for the tape-bonded specimens with those for the liquid-adhesive-bonded sepecimens provided a basis for evaluating the relative creep-rupture response of the two types of bonding systems. Similarly, a comparison of the fitted curves for the replicate data sets of each adhesive system gave a measure of the batch-to-batch reproducibility of the creep-rupture data. The major conclusion was that the tape-bonded specimens had times-to-failure that were, in most cases, comparable to or greater than those of the liquid-adhesive-bonded specimens. And, the tape-bonded specimens provided time-to-failure results that were reproducible between replicate sets.

S

Sadek, F.; Mohraz, B.
Modified Optimal Algorithm for Active Structural Control.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5782; 29 p. January 1996.
Available from National Technical Information Service
PB96-165949

building technology; active control; control algorithms; optical control; structural dynamics

This study presents a modification to two linear optimal control algorithms, namely classical and instantaneous, to achieve a greater reduction in structural displacements and control forces. The modification consists of building a library of gain matrices and selecting the gain matrix that would result in the maximum control force without exceeding the control system capacity. The modification was used to compute the response of several single-degree-of-freedom (SDOF) systems, a multi-degree-of-freedom (MDOF) system, and a base isolated structure. Based on the examples considered, the modification results in a reduction

of up to 45% in the peak control forces and structural displacements as compared to existing algorithms. The study shows that the external excitation influences the selection of the control system parameters such as controller capacity and gain matrices. These parameters, therefore, should be determined according to the seismic excitation intensity expected at the site.

Sadek, F.; Mohraz, B.; Lew, H. S.
Single and Multiple Tuned Liquid Column Dampers for Seismic Applications.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5920; 45 p. November 1996.
Available from National Technical Information Service
PB97-132062

dampers; seismic loads; earthquakes; statistical analysis

The optimum parameters of single and multiple tuned liquid column dampers (TLCD) for reducing the response of structures to seismic loads are presented. A deterministic analysis is carried out using 72 earthquake ground motion records to determine the optimum tuning ratio, tube width to liquid length ratio, and head loss coefficient corresponding to a given mass ratio for single tuned liquid column dampers (STLCD). A similar analysis is performed to determine the optimum central tuning ratio, tuning bandwidth, and grouping of dampers for multiple tuned liquid column dampers (MTLCD). The optimum parameters are used to compute the response of several single-degree-of-freedom structures and one multi-degree-of-freedom structure with single and multiple TLCDs to different earthquake excitations. The study indicated that: (a) the use of the optimum parameters reduces the displacement and acceleration responses; (b) MTLCDs have a slight advantage over STLCDs in reducing the response; and (c) MTLCDs are robust to errors in estimating the structural parameters. The solution from an analysis using TLCDs is compared with that using tuned mass dampers where it is found that both devices result in comparable reductions in the response. Design examples using STLCDs and MTLCDs in a simple bridge model and in a ten-story structure are presented to illustrate how the parameters are selected and demonstrate the performance of the devices under different ground excitations.

Sadek, F.; Mohraz, B.; Taylor, A. W.; Chung, R. M.
Method of Estimating the Parameters of Tuned Mass Dampers for Seismic Applications.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5806; 39 p. April 1996.
Available from National Technical Information Service
PB96-167820

building technology; earthquake engineering; passive control; structural dynamics; tuned mass dampers

The optimum parameters of tuned mass dampers (TMD) that result in considerable reduction in the response of structures to seismic loading are presented. The criterion used to obtain the optimum parameters is to select, for a given mass ratio, the frequency (tuning) and damping ratios that would result in equal and larger modal damping in the first two modes of vibration. The parameters are used to compute the response of several single and multi-degree-of-freedom structures with TMDs to different earthquake excitations. The results indicate that the use of the proposed parameters reduces the displacement and acceleration responses significantly. The method can also be used in vibration control of tall buildings in the so called "mega-substructure configuration," where substructures serve as vibration absorbers for the parent structure. It is shown that as a result of selecting the parameters as proposed in this paper, significant reduction in the response of tall buildings can be achieved.

Schlangen, E.; Garboczi, E. J.
New Method for Simulating Fracture Using an Elastically Uniform Random Geometry Lattice.
Delft University of Tchnology, The Netherlands
National Institute of Standards and Technology, Gaithersburg, MD
International Journal of Engineering Science, Vol. 34, No. 10, 1131-1144, 1996.
building technology; beam theory; concretes; elasticity; fracture; homogeneoty; lattice; microstructure

This paper discusses 2D lattice models of beams for simulating the fracture of brittle materials. A simulation of an experiment on a concrete plate subjected to shear, in which two overlapping cracks occur, is used to study the effect of individual beam characteristics and different arrangements of the beams in the overall lattice. It was found that any regular orientation of the beams influences the resulting crack patterns. A method is developed to construct a lattice with a random geometry, but which can represent a homogeneous medium, that eliminates the influence of the beam orientation on a simulated crack pattern. Methods to implement a wide range of Poisson's ratios are also developed, and the use of the random lattice to study arbitrary microstructures is outlined. The crack patterns that are obtained with this lattice are in good agreement with the experimental results.

Schwartz, L. M.; Garboczi, E. J.; Bentz, D. P.
Interfacial Transport in Porous Media: Application to dc Electrical Conductivity of Mortars.
Schlumberger-Doll Research, Ridgefield, CT
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Applied Physics, Vol. 78, No. 10, 5898-5908, November 15, 1995.
building technology; concretes; durability; effective medium theory; electrical conductivity; interfacial zone; mortar; percolation; fluid flow

A mortar is a composite of inert sand grains surrounded by a porous cement paste matrix. We investigate the electrical conductivity of model mortars that include enhanced electrical conduction in the matrix-sand grain interfacial region. The electrical conductivity is evaluated by a combination of finite element, finite difference, and random walk methods for periodic and disordered models of mortar. Since the effective conductivity within the interfacial zone is often much higher than the bulk matrix conductivity, the qualitative features of transport in these systems is often controlled by the connectivity of the interfacial zone. Special attention is thus given to the geometrical percolation of this zone. A family of effective medium approximations give a good qualitative description of the disordered model's electrical properties. A simple four parameter Pade approximant is found to successfully describe the electrical conductivity of the periodic model over the entire range of parameters studied. Finally, we show that our calculations can be used to obtain a reasonable estimate of the permeability to viscous fluid flow.

Seem, J. E.; House, J. M.
Control System That Prevents Air From Entering an Air-Handling Unit Through the Exhaust Air Damper.
Johnson Controls, Inc., Milwaukee, WI
National Institute of Standards and Technology, Gaithersburg, MD
Optimum Ventilation and Air Flow Controls in Buildings. AIVC 17th Annual Conference. Proceedings. Volume 2. September 1996, Gothenberg, Sweden, 562-569 pp, 1996.
airflow; air handling unit; indoor air quality; simulation

Traditional air-handling unit (AHU) control systems link the position of the exhaust air damper, recirculation air damper, and outdoor air damper. Tests at the National Institute of Standards and Technology (NIST) on a variable-air-volume (VAV) AHU have shown that air can enter the AHU through the exhaust air damper. This can negatively impact indoor air quality if the exhaust air duct is located near a pollution source. This paper presents a new control system for variable air volume AHU's that use volume matching to control the return fan. The new control system links only the position of the exhaust air damper

and recirculation air damper. During occupied times, the outdoor air damper is in the fully open position. Simulation and laboratory results are presented to compare the new control system and a traditional control system. Several cases are simulated to examine the effect of damper sizing and system load on airflow in AHU's. The simulations demonstrate that the new control system can prevent air from entering the AHU through the exhaust air damper for conditions that the traditional control system cannot. A case demonstrating the limits of the new control system to prevent this phenomenon is included in the simulation results. The laboratory results provide further evidence that the new control system prevents air from entering the AHU through the exhaust air damper for conditions that cause the phenomenon with the traditional control system.

Serio, M. A.; Bonanno, A. S.; Knight, K. S.; Newman, J. S.
Fourier Transform Infrared Diagnostics for Improved Fire Detection Systems.
Advanced Fuel Research, Inc., East Hartford, CT
Factory Mutual Research Corp., Norwood, MA
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 115-116 pp, 1996.
Available from National Technical Information Service

fire research; fire science; fire detection systems; ft-ir; false alarms

A major advance in the past two decades is the availability of low cost smoke detectors based on either ionization or photoelectric detectors. However, these detectors have some drawbacks because of the high frequency of false alarms. Other types of detector technologies have been developed for specific gases, such as CO2, CO, or O2, based on metal oxide semiconductors, electrochemical sensors, or optical sensors. However, all single parameter methods are hindered by the lack of generality for several types of fires and a lack of "intelligence," i.e., not always being able to discriminate against false signals. The objective of this study was to demonstrate the feasibility of an Fourier Transform Infrared (FT-IR) spectroscopy based fire detection system. This work involved four tasks: [1] modification of an FT-IR spectrometer system to investigate three different detection modes (open-path, cross-duct, extraction into a multi-pass cell); [2] FT-IR measurements in the three modes for several types of flames; [3] investigation of advanced signal processing techniques for data analysis; [4] preliminary design of a prototype fire detection system. The types of fires examined included polymethyl methacrylate (PMMA), polystyrene (PS), polyvinyl chloride (PVC), polyurethane, douglas fir, methanol, hexane and heptane.

Seshadri, K.
Chemical Inhibition of Methane-Air Diffusion Flame. Final Report. September 15, 1993-September 15, 1995.
University of California, San Diego, La Jolla
NIST-GCR-95-685; 41 p. June 1996.
Available from National Technical Information Service
PB96-195532

diffusion flames; chemical inhibition; air; bromotrifluoromethane; carbon monoxide; fire research; hydrogen; methane; trifluoromethane; water

The principal objective of this research is to clarify the mechanisms of chemical inhibition of methane-air diffusion flames by CF3Br and CF3H. An experimental, numerical and analytical study is conducted. In inhibited flames at conditions close to flame extinction significant amount of oxygen is found to leak through the reaction zone. Therefore an asymptotic analysis is performed to characterize the structure and critical conditions of extinction of uninhibited methane-air diffusion flames. Later this analyses is extended to methane-air diffusion flames inhibited with CF3Br. Citical conditions of extinction of the flame are measured over a wide range with agents added to the air stream and to the fuel stream. Numerical calculations with detailed chemistry are performed to calculate the structure and critical conditions of flame extinction. The numerical results are compared with the measurements.

Shaddix, C. R.; Smyth, K. C.
Laser-Induced Incandescence Measurements of Soot Production in Steady and Flickering Methane, Propane, and Ethylene Diffusion Flames.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 107, No. 4, 418-452, 1996.

soot; diffusion flames; methane; propane; ethylene; atmospheric pressure; lasers; light scattering

Quantitative experimental measurements of soot concentrations and soot scattering are presented for a series of steady and flickering coflowing methane, propane, and ethylene flames burning at atmospheric pressure. Flickering diffusion flames exhibit a wide range of time-dependent, vortex-flame sheet interactions, and thus they serve as an important testing ground for assessing the applicability of chemical models derived from steady flames. Acoustic forcing of the fuel flow rate is used to phase lock the periodic flame flicker close to the natural flame flicker frequency caused by buoyancy-induced instabilities. For conditions in which flame clip-off occurs, the peak soot concentrations in the methane flickering flames are 5.5 to 6 times larger than flickering propane and ethylene flames is only 35% to 60%, independent of the flicker intensity. Soot concentration profiles and full Mie analysis of the soot volume fraction/scattering results reveal significant differences in the structure of the soot fields and in the roles of soot inception, growth, and oxidation for the different hydrocarbon fuels. The soot concentrations have been measured using laser-induced incandescence (LII). Since this is the only technique currently available for making time- and spatially-resolved soot concentration measurements in time-varying flow fields, considerable effort has been devoted to developing LII for quantitative applications. Important considerations include (1) proper calibration measurements, (2) signal detection which minimizes interferences from C2 Swan-band emission and broadband molecular fluorescence, (3) correction for the laser beam focus/spatial averaging effect in line image measurements, and (4) correction for LII signal extinction within the flame.

Shenton, H. W., III
Guidelines for Pre-Qualification, Prototype and Quality Control Testing of Seismic Isolation Systems.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5800; 143 p. January 1996.
Available from National Technical Information Service
PB96-193685

seismic isolation systems; quality control

Testing has become an essential element in the design and construction of seismically base isolated structures. Prototype tests and quality control tests of the isolation system are currently required by the 1994 "Uniform Building Code" and the American Association of State Highway and Transportation Officials 1991 "Guide Specifications for Seismic Isolation Design." However, standards do not exist for conducting these tests. The Building and Fire Research Laboratory of the National Institute of Standards and Technology has developed guidelines for testing and evaluation of seismic isolation systems. The guidelines were developed in close cooperation with industry, researchers and practitioners. Included in this report are comprehensive guidelines for conducting pre-qualification, prototype and quality control tests of the isolation system. The guidelines are independent of the type of isolation system and application. Thus, they can be used to test elastomeric, sliding or hybrid isolation system and application. Thus, they can be used to test elastomeric, sliding or hybrid isolation systems, for applications that involve buildings, bridges, facilities and other special structures. The guidelines include general requirements of the test facility, instrumentation, calibration, data acquisition, data analysis and reporting of results. All tests are presented in a standard format that includes the following elements: test designation, purpose, sequence, procedure, performance criteria, special requirements and exceptions. The guidelines are to serve as a resource document for voluntary standard/specification writing organizations, and for practitioners and researchers involved in the design, manufacture and testing of seismic isolation systems.

Shenton, H. W., III; Taylor, A. W.; Lew, H. S.
Test Requirements for Base Isolation.
National Institute of Standards and Technology, Gaithersburg, MD
U.S./Japan Cooperative Program in Natural Resources. Panel on Wind and Seismic Effects. Joint Meeting, 27th. Proceedings. Public Works Research Institute Technical Memorandum 3387. May 16-19, 1995, Tsukuma, Japan, 81-87 pp, 1995.

base isolation; bridges (structures); earthquake engineering; elastomeric bearings; seismic design; siding systems; standards; tests

In the United States there are currently no widely accepted standards for the testing and evaluation of seismic base isolation systems for buildings, bridges and ohter civil engineering structures. It is difficult for designers to evaluate the characteristics of a given system, or to compare competing systems, since standard test methods and properties of systems have never been clearly defined. This paper describes guidelines, recently developed at the National Institute of Standards and Technology (NIST), for testing and evaluation of seismic isolation systems. The guidelines are intended to apply to any type of civil engineering structure. In this paper the philosophy behind the development of the guidelines is first discussed. Then the guidelines themselves are briefly reviewed, and the three types of tests recommended by the guidelines are described: pre-qualification, prototype, and quality control testing. Finally, future research and standards development activities related to the guidelines are outlined.

Simiu, E.
Melnikov Process for Stochastically Perturbed, Slowly Varying Oscillators: Application to a Model of Wind-Driven Coastal Currents.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Applied Mechanics, Vol. 63, 429-435, June 1996.

chaos; currents; dynamical systems; mean exit time; melnikov function; ocean engineering; stochastic differential equations; wind engineering

The stochastic Melnikov approach is extended to a class of slowly varying dynamical systems. It is found that (1) necessary conditions for chaos induced by stochastic perturbations depend on the excitation spectrum and the transfer function in the expression for the Melnikov transform; (2) the Melnikov approach allows the estimation of lower bounds for (a) the mean time of exit from preferred regions of phase space, and (b) the probability that exits from those regions cannot occur during a specified time interval. For a system modeling wind-induced currents, the deterministic Melnikov approach would indicate that chaotic transport cannot occur for certain parameter ranges. However, the more realistic stochastic Melnikov approach shows that, for those same parameter ranges, the necessary conditions for exits during a specified time interval are satisfied with probabilities that increase as the time interval increases.

Simiu, E.; Franaszek, M.
Melnikov-Based Open-Loop Control of Escape for a Class of Nonlinear Systems.
National Institute of Standards and Technology, Gaithersburg, MD
American Society of Mechanical Engineers. Design Engineering Technical Conferences. Proceedings. DE-Vol. 84-1. Book No. H1000A. 1995, Cudney, H. H.; Sinha, S. C.; Cusumano, J. P.; Pfeiffer, F., Editors, 897-902 pp, 1995.

building technology; control; dynamical systems; nonlinear dynamics; random vibration; stochastic dynamics

The performance of certain nonlinear stochastic systems is deemed acceptable if, during a specified time interval, the systems have sufficiently low probabilities of escape from a preferred region of phase space. We propose an open-loop control method for reducing these probabilities. The method is applicable to stochastic systems whose dissipation- and excitation-free counterparts have homoclinic or heteroclinic ortibs. The Melnikov relative scale factors are system properties containing information on the frequencies of the random forcing spectral components that are most effective in inducing escapes. This

information is useful in practice even if the dissipation and excitation terms are relatively large. An ideal open-loop control force applied to the system would be equal to the negative of a fraction of the exciting force from which the ineffective components have been filtered out. Limitations inherent in any practical control system make it impossible to achieve such an ideal control. Nevertheless, numerical simulations show that substantial advantages can be achieved in some cases by designing control systems that take into account the information contained in the Melnikov scale factors.

Simiu, E.; Franaszek, M.
New Tool for the Investigation of a Class of Nonlinear Stochastic Differential Equations: The Melnikov Process.
National Institute of Standards and Technology, Gaithersburg, MD
Advances in Nonlinear Stochastic Mechanics IUTAM Symposium. Proceedings. July 3-7, 1995, Trondheim, Norway, Kluwer Academic Publishers, Boston, MA, Naess, A.; Krenk, S., Editors, 427-463 pp, 1996.

building technology; chaotic dynamics; control theory; nonlinear dynamics; oceanography; stochastic differential equations; structural engineering

The Melnikov process, a construct rooted in chaotic dynamics theory, was recently developed as a tool for the investigation of a broad class of nonlinear stochastic differential equations. This paper briefly reviews the stochastic Melnikov-based approach and applications to (1) oceanography (2) open-loop control of stochastic nonlinear systems and (3) snap-through of buckled beams with distributed mass and distributed random loading.

Simiu, E.; Frey, M.
Noise-Induced Sensitivity to Initial Conditions.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
Fluctuations and Order: The New Synthesis. Proceedings. Chapter 6. 1996, Springer, New York, NY, Millonas, M., Editor, 81-90 pp, 1996.

building technology; chaos; Melnikov function; noise (sound); ocean engineering; sensitivity to initial conditions; stochastic equations; structural engineering

Deterministic chaos and noise-induced basin hopping are closely related in a broad class of multistable dynamical systems. A necessary condition for sensitivity to initial conditions, based on the generalized Melnikov function and originally derived for deterministic systems, can be extended to systems excited by noise. This extension involves the representation of noise processes as sums of terms with random parameters. Gaussian noise and shot noise can be accommodated for both additive and multiplicative excitations. Our extension of the Melnikov approach shows that, for the class of noise-excited systems being considered, basin hopping implies sensitivity to initial conditions. Applications of this approach to noise-excited systems are discussed.

Simiu, E.; Frey, M. R.
Melnikov Processes and Noise-Induced Exits From a Well.
National Institute of Standards and Technology, Gaithersburg, MD
Bucknell Univ., Lewisburg, PA
Journal of Engineering Mechanics, Vol. 122, No. 3, 263-270, March 1996.

building technology; dichotomous noise; dynamical systems; function; stochastic dynamical systems

For a wide class of near-integrable systems with additive or multiplicative noise the mean zero upcrossing rate for the stochastic system's Melnikov process, provides an upper bound for the system's mean exit rate. Comparisons between Melnikov process and mean exit rate show that in the particular case of additive white noise this upper bound is weak. For systems excited by processes with tail-limited distributions, the stochastic Melnikov approach yields a simple criterion guaranteeing the

nonoccurrence of chaos. This is illustrated for the case of excitation by square-wave, coin-toss dichotomous noise. Finally, we briefly review applications of the stochastic Melnikov approach to a study of the behavior of wind-induced fluctuating currents over a corrugated ocean floor; the snap-through of buckled columns with continuous mass distribution and distributed random loading; and open-loop control of stochastically excited multistable systems.

Simiu, E.; Heckert, N. A.; Whalen, T.
Estimates of Hurricane Wind Speeds by the 'Peaks Over Threshold' Method.
National Institute of Standards and Technology, Gaithersburg, MD
Johns Hopkins Univ., Laurel, MD
NIST TN 1416; 49 p. February 1996.
Available from Government Printing Office
SN003-003-03396-1
Available from National Technical Information Service
PB96-162540

weather effects; hurricanes; building technology; building codes; climatology; extreme value theory; load factors; structural engineering; structural reliability; threshold methods; wind (meteorology)

We report results that lend support to the hypothesis that extreme hurricane wind speeds are described predominantly by reverse Weibull distributions, which have limited upper tails. The results are based on the analysis of hurricane wind speed data obtained in an earlier project and used for the development of the ASCE 7-83 and ASCE 7-93 Standard wind speed map. According to our results, wind load factors should be larger in hurricane-prone regions than the load factor specified in current standard provisions. However, the requisite increases are smaller than would be the case if the distributions were assumed to have infinite upper tails, as has been done so far in all principal studies of hurricane winds in the United States.

Simiu, E.; Heckert, N. A.
Extreme Wind Distribution Tails: A "Peaks Over Threshold" Approach.
National Institute of Standards and Technology, Gaithersburg, MD
Journal of Structural Engineering, Vol. 122, No. 5, 539-547, May 1996.
NIST BSS 174; 77 p. March 1995.

extreme value theory; threshold methods; wind effects; meteorology; building technology; building codes; climatology; load factors; structural engineering; wind velocity; structural reliability

We seek to ascertain whether the reverse Weibull distribution is an appropriate extreme wind speed model by performing statistical analyses based on the "peaks over threshold" approach. We use the de Haan method, which was found in previous studies to perform about as well or better than the Pickands and Cumulative Mean Exceedance methods, and has the advantage of providing estimates of confidence bounds. The data are taken principally from records of the largest daily wind speeds obtained over periods of 15 to 26 years at 44 U.S. weather stations in areas not subjected to mature hurricane winds. From these records we create samples with reduced mutual correlation among the data. In our opinion, the analyses provide persuassive evidence that extreme wind speeds are described predominantly by reverse Weibull distributions, which unlike the Gumbel distribution have finite upper tail and lead to reasonable estimates of wind load factors. Instructions are provided for accessing the data and attendant programs.

Sivathanu, Y. R.; Tseng, L, K.
Fire Detection Using Near-IR Radiation and Source Temperature Discrimination.
Purdue Univ., West Lafayette, IN
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 117-118 pp, 1996.
Available from National Technical Information Service

fire research; fire science; fire detection; infrared radiation; source temperature; fire detectors

New fire detection concepts and algorithms are justified only if they improve upon existing ones with lower false alarm rates and greater sensitivity to starting fires. In addition, the detectors and signal processing instruments should be easy to operate and maintain, have high flexibility and be relatively inexpensive. Currently residential fire detectors include optical smoke sensors, ionization smoke sensors and temperature sensors. Conventional smoke sensors utilize light scattering or smoke ionization measurements, while temperature sensors utilize thermocouple measurements. The disadvantages with conventional single sensor detectors are that there is a significant time delay between the start of the fire, and the transport of either combustion products or smoke to positions close enough to enable detection and single sensor detectors involve a high rate of false alarms due to changes in the operating environment. Combinations of smoke sensors and odor sensors which involve multiple fire signatures are less prone to false alarms, but involve greater initial and maintenance costs. The objective of the present work was to investigate whether these two characteristics of natural fires could be exploited in a near-infrared fire detector operating on the principle of source temperature discrimination.

Smyth, K. C.
NO Production and Destruction in a Methane/Air Diffusion Flame.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion Science and Technology, Vol. 115, 151-176, 1996.

nitric oxide; diffusion flames; kinetics; lasers; methane

Concentration profiles have been measured for naturally occurring NO in a lamainar CH4/air diffusion flame burning on a rectilinear Wolfhard-Parker slot burner at atmospheric pressure. Linear laser-induced fluorescence of the [see journal article] (0,0) transition was excited using a frequency doubled tunable dye laser and detected with a dielectric filter/photomultiplier tube combination. The observed fluorescence signals have been corrected for (1) the Boltzmann population in the R1(17) rotational level of the ground vibronic state and (2) collisional quenching rates as a function of the local temperature and collider concentrations. The resulting relative concentration profiles have been calibrated using tunable diode laser absorption measurements of Hill and Miller. Both the overall NO production/destruction rates and the contributions from individual elementary steps have been derived; the later analysis utilizes previously measured profiles of H, O, OH, CH, and CH3 as well as an estimated 3CH2 profile. The NO profile measuremnets alone do not distinguish its dominant production pathway in this co-flowing CH4/air flame, since the contribution of prompt NO production is obscured by competing CHi + NO destruction reactions. As a consequence of these reburn reactions, the observed peak NO concentrtions are observed to closely track the maximum temperatures. A reaction path analysis and determination of NO fluxes strongly indicate that prompt NO production outweighs the thermal route, but uncertainities in determining the relative contributions to instantaneous NO production are large.

Smyth, K. C.; Shaddix, C. R.
Elusive History of m=1.57-0.56i for the Refractive Index of Soot. Brief Communication.
National Institute of Standards and Technology, Gaithersburg, MD
Combustion and Flame, Vol. 107, No. 3, 314-320, November 1996.

soot; refractive index

Soot volume fractions, number densities, and particle sizes have been extensively measured in laboratory flames using combined extinction and scattering methods. In order to obtain quantitative results, a value of the complex refractive index

of the soot must be chosen, appropriate for the wavelength employed in the experimental measurements. Recent quantitative soot volume fraction determinations using laser-induced incandesence also rely on a proper calibration, which is usually based on extinction-derived soot concentrations. Soot refractive indices have been reported for over 30 years, during which time measurement techniques have evolved considerably. Extractive, room-temperature compressed pellet reflectance methods have been replaced, for example, by in situ determinations using combined classical and dynamic light scattering. Despite many measurements of the refractive index of soot, m=1.57 - 0.56i is still by far the result most often cited in the combustion community for visible wavelengths. This value has been widely attributed to Dalzell and Sarofim, although it is not included in their experimental data in either the visible or near-IR wavelength regions.

Snell, J. E.
Future Needs for Fire Safety Knowledge and Tools.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Design of Buildings and Fire Safety Engineering. Conference Compendium. Proceedings. Session 4: Fire Safety Analyses. August 19-20, 1996, Oslo, Norway, 1-1 pp, 1996.

fire safety; building codes; safety engineering; fire research

Most of the papers presented in this symposium address advances in the development of performance-based fire safety building codes and some of the tools upon which they rest. This presentation will revert to the somewhat broader perspective on the scope of fire safety engineering presented earlier and focus on needs and critical gaps as a basis for setting priorities for internaitonal fire research. It builds on recent work of the FORUM and the author's own laboratory. Items on this list should be the things for which we seek common sources and mechanisms of support via approaches such as that outlined by Richardson, so that the promise and fruits of FSE fall within our collective reach. Advances in other fields of science and technology are fueling important innovations in fire research. Some examples will be discussed.

Snell, J. E.
Presentation of Forum for International Cooperation on Fire Research.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Safety Design of Buildings and Fire Safety Engineering. Conference Compendium. Proceedings. Session 1: Fire Safety Building Codes. August 19-20, 1996, Oslo, Norway, 1-1 pp, 1996.

fire safety; building codes; safety engineering; fire research

The Forum for International Cooperation on Fire Research, FORUM, is an informal group of heads of fire research organizations throughout the world. Its aim is to reduce the burden of fire through international cooperation. Towards this end, the FORUM has four general objectives: promote fire research, facilitate technology transfer, optimize the use of scarce resources for fire research, and advance fire safety engineering. Particularly relevant to this symposium is the last of these objectives, advance fire safety engineering. Doing this requires a scientifically-based knowledge of fire; recognized calculational tools and reliable data; and recognized professional status for the discipline of FSE with appropriate education and training of its practitioners. The organizations which we head provide the technical basis for much of this through our research, and we provide support and encouragement for the rest through participation in international technical and standardization organizations, and international conference and symposia such as this one.

Snyder, K. A.; Clifton, J. R.; Pommersheim, J.
Computer Program to Facilitate Performance Assessment of Underground Low-Level Waste Concrete Vaults.
National Institute of Standards and Technology, Gaithersburg, MD

Materials Research Society. Materials Research Society Symposium Proceedings Volume 412. 1996, 491-498 pp, 1996.

building technology; concretes; vaults; computer programs; degradation; advection diffusion; chemical equilibrium; physical parameters; validation

A computer program (4SIGHT) to facilitate performance assessment of underground concrete vaults for low level waste (LLW) disposal facilities is being developed at the National Institute of Standards and Technology (NIST). Specifically, the program predicts the hydraulic conductivity and the service life of an underground concrete vault. The hydraulic conductivity estimate is based upon empirical relations. The service life is estimated from consideration of three major degradation processes: steel reinforcement corrosion, sulfate attack, and leaching. The performance prediction is based upon ion transport equations for both diffusion and advection. Most importantly, the computer program incorporates the synergistic degradation effects of all three processes, and their effect upon the transport coefficients.

Sorathia, U.; Lyon, R.; Gann, R. G.; Gritzo, L.
Materials and Fire Threat.
Naval Surface Warfare Center, Annapolis, MD
Federal Aviation Administration, Atlantic City International Airport, NJ
National Institute of Standards and Technology, Gaithersburg, MD
Sandia National Labs., Albuquerque, NM
SAMPE Journal, Vol. 32, No. 3, 8-15, May/June 1996.

composite materials; load bearing elements; structures; fire growth; habitability; fire extinguishment; fire safety; flammability; fire barriers

Polymer research is producing new materials with exceptional properties, and products made with these materials may well replace many conventional products. Fiber-reinforced polymer composites offer the U.S. Military the potential for significant reductions in weight and signatures. Current seaborne applications of composite materials in the U.S. Navy include sonar bow domes and windows, and coastal minehunter MHC-51 hulls. The U.S. Navy is also evaluating composite materials for both primary and secondary load-bearing structures wuch as foundations, deckhouses, and hulls; machinery components such as composite piping, valves, centrifugal pumps, and heat exchangers; and auxiliary or support items such as gratings, stanchions, ventilation ducts, and screens. This new interest in composite materials is due to increased need for a corrosion-free, lightweight, and affordable low-cost alternative to metallic components. The U.S. Army is evaluating composite combat vehicles and the U.S. Air Force has taken the lead in transitioning composite technology to military advantage as evidenced by superior performance of the Stealth Fighter.

Sorensen, C. M.
Post-Flame Soot. Final Report. September 1994-December 1995.
Kansas State Univ., Manhattan
NIST-GCR-96-694; 34 p. June 1996.
Available from National Technical Information Service
PB96-193701

soot; acetylene; diffusion flames; flame research; light scattering; smoke

The smoke agglomerates produced by a co-annular diffusion flame with acetylene fuel were characterized by sampling/microscopy and light scattering measurements. Particles were sampled at various heights above the flame using both thermophoretic sampling and impaction. Transmission electron microscopy was used for the smaller agglomerates obtained by thermophoretic sampling and optical microscopy was used for analysis of particles as large as .4 mm in diamter collected by impaction. The number of primary spheres was estimated from the projected area of the agglomerate and the primary sphere size. The fractal analysis extended over four orders of magnitude in the radius of gyration - the widest range studied for smokes. The fractal dimension and the prefactor were determined for smoke collected for a range of heights above the flame. The structure factor measurements were performed for angles ranging from 1DG to 150DG as a function of height and fuel flow. No Guinier regime was observed at a flow rate of 30 ml/min. Modeling results suggest that the slight dip in the structure

factor measurements might result from intercluster scattering. A condition for the transition from Brownian agglomeration to gelation is derived.

Spellerberg, P. A.; Trimm, W. L.; Pielert, J. H.
Development and Application of a Quality System Standard for Construction Materials Testing Laboratories.
National Institute of Standards and Technology, Gaithersburg, MD
Missouri Highway and Transportation Department, Jefferson City, MO
Journal of Testing and Evaluation, Vol. 24, No. 1, 49-55, January 1996.

accreditation; construction materials; laboratory; quality; standards; testing

The American Association of State Highway and Transportation Officials (AASHTO) Accreditation program (AAP) was initiated by AASHTO in 1988 as a tool for promoting the quality of testing in construction materials laboratories. The program currently has around 120 laboratories accredited for testing of various construction materials. In the program it became apparent that there was a need to provide specific guidance to laboratories in preparing and implementing a quality system. In response, AASHTO prepared Recommended Practice R18-92I, "Establishing and Implementing a Quality System for Construction Materials Testing Laboratories." While generally based on existing ASTM and International Standards Organization (ISO) standards, Practice R18 is much more definitive in regard to evaluation criteria for construction materials laboratories. It includes an appendix that provides illustrated examples of documents, forms, and standard operating procedures, which may be used by the laboratory in preparing a quality manual. Practice R18 has been adopted for use in the AASHTO Materials Reference Laboratory (AMRL) Laboratory Inspection Program, and became mandatory for laboratories participating in the AASHTO Accreditation program in April 1994. This paper presents an overview of Practice R18 and its use in the AMRL Laboratory Inspection program and the AASHTO Accreditation Program.

Steckler, K. D.; Grosshandler, W. L.
Heat Flux Calibration Flow and Conduction Facilities: Status Report.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 31-32 pp, 1996.
Available from National Technical Information Service

fire research; fire science; heat flux; convective heat transfer; conductive heat transfer

Standard methods exist at NIST for calibrating thermal radiation detectors up to 10kW/m2 using blackbody cavities, and up to 40 kW/m2 using a monochromatic laser source. Heat flux transducers, however, are often used under conditions where convection dominates, where radiation emanates from a source with a different spectral character, or where flux levels exceed 40 kW/m2. The objective of this project is to extend NIST heat flux calibration capabilities to, at least, a limited range of the latter conditions. Convective and conductive heat transfer facilities are being designed and constructed for this purpose.

Stone, W. C.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5856; 156 p. May 1996.
National Institute of Standards and Technology. NIST Construction Automation Program, Report No. 2. NIST Construction Automation Workshop. Proceedings. March 20-31, 1995, 1996.
Available from National Technical Information Service
PB96-202239

automated building construction; automated excavation; construction automation; construction robotics; data exchange standards; helmet mounted displays; laser metrology; non-line-of-sight metrology; telemetry; virtual reality displays; wireless communication

A two-day workshop on Construction Automation was hosted at NIST during March 30-31, 1995. Research programs actively underway at NIST in this area include the development of sensing systems, hardware, and software algorithms for advanced real time construction site metrology; wide band telemetry and data acquisition [the ability to track many sensors at once through wireless communications]; virtual site simulation and object representation standards [development of robust virtual reality models for construction site objects and machines]; person-in-loop systems [including head-up displays, virtual simulators, tele-operations workstations, and portable database interrogators]; and semi-autonomous machine operations. These topics, and the need for database and machine interfacing standards, were discussed by workshop participants representing industry, government, and academe. Specific invited presentations included laser distancing, non-line-of-sight and kinematic GPS metrology, automated data exchange standards, real-time kinematic modeling, military helmet-mounted displays, virtual reality displays, construction robotics, automated excavation, virtual site representation, and automated building construction.

Stone, W. C.
NIST Construction Automation Initiative.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5856; May 1996.
National Institute of Standards and Technology. NIST Construction Automation Program, Report No. 2. NIST Construction Automation Workshop. Proceedings. Chapter One: Topical Lectures. Paper 1.3. March 20-31, 1995, 13-21 pp, 1995.
Available from National Technical Information Service
PB96-202239

construction; technology transfer; robotics

Before we get started, let me introduce a few key people who have helped to organize this workshop. I would like to thank Ken Goodwin from the Manufacturing Engineering Laboratory (MEL), Kent Reed from the Building and Fire Research Laboratory (BFRL), and Jim Albus and Nick Dagalakis, also from MEL. One of the reasons that we are here is to see where we might be able to go with future construction technologies. I would like to open with the thought that "It's already been done." An I have a video to prove it.

Stone, W. C.
NIST Construction Automation Program Report No. 1: Non-Line-of-Sight (NLS) Construction Metrology.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5825; 217 p. February 1996.
Available from National Technical Information Service

construction automation; dielectric constant; diffraction; metrology; multipath; NLS; non-line-of-sight; penetration capacity; positioning system; propagation delay; spread spectrum radar; surveying

This paper addresses the subject of automated metrology (surveying) for use on construction sites. Specifically, the research is directed to the development of a novel Non-Line-of-Sight (NLS) system with which the real-time position and orientation (attitude) of any object on a construction jobsite may be determined, irrespective of the presence of intervening obstacles that would otherwise render optical and/or electro-optical techniques useless. Tests were conducted using a specially configured broad-band, low-frequency spread-spectrum radar. The transmission and receiving antennae, which in normal radar are typically one and the same, were physically separated so as to create a system with a fixed broadcast unit and a "roving" receiver, whose range was to be determined relative to the transmission antenna by means of time-of-arrival measurements. Time domain response was synthesized by means of fourier theory from a broad spectrum of data sampled in the frequency

domain. Numerous field experiments were performed in which typical construction site obstacles were placed between the transmitter and receiver with separation distances of up to 80 meters. The obstacles included a half-meter thick, heavily reinforced concrete wall, varying combinations of masonry block and brick up to more than a meter in thickness, and metal pre-fabricated wall panels. In all but the latter case, repeatable distances were obtained. Range detection was lost in the presence of extensive metal panels that contained no windows. However, the presence of even small openings permitted range acquisition. Sources of error, limits of resolution and accuracy, and factors affecting time of flight measurement are discussed.

Stone, W. C.
Real-Time GPS and Non-Line-of-Sight Metrology.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5856; May 1996.
National Institute of Standards and Technology. NIST Construction Automation Program, Report No. 2. NIST Construction Automation Workshop. Proceedings. Chapter One: Topical Lectures. Paper 1.5. March 20-31, 1995, 29-41 pp, 1995.
Available from National Technical Information Service
PB96-202239

construction; technology transfer; robotics

I would like to pick up where Eric left off and describe the results of research which is currently underway at NIST in the field of construction metrology. Earlier I indicated that there were many technological steps along the way to implementing the real benefits of automation at a construction site. The underpinning of all of this is the need to know where things are. In the past this need has been met (in a minimal way) by static benchmarks and survey stakeouts provided by field crews. Even with digital total stations and laser or infrared based electronic distancing, this is a slow and tedious process. And it must be repeated many times during the course of a construction job as the geometry of the worked terrain changes.

Stutzman, P. E.
Guide for X-Ray Powder Diffraction Analysis of Portland Cement and Clinker.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5755; 43 p. March 1996.

clinker; phase composition; portland cement; quantitative analysis; qualitative analysis; x-ray powder diffraction

Accurate, rapid methods for determining phase abundance are necessary to aid in classification of cements and for correlation of performance characteristics with composition. X-ray powder diffraction is a direct method for qualitative and quantitative phase abundance analysis of fine-grained materials. While the application of powder diffraction in the cement industry is well established for qualitative analysis, its use in the determination of phase abundance is not as common. This guide examines methods for compositional analysis of portland-cement clinker and cement by X-ray powder diffraction through examples of diffraction pattern profile regions used in phase and polymorph identification, and demonstration of a procedure for calibration and quantitative phase abundance analysis.

Stutzman, P. E.
Pattern Fitting for Quantitative X-Ray Powder Diffraction Analysis of Portland Cement and Clinker.
National Institute of Standards and Technology, Gaithersburg, MD
International Conference on Cement Microscopy, 18th. International Microscopy Association. Proceedings. April 21-25, 1996, Houston, TX, Intl. Cement Microscopy Assoc., Duncanville, TX, Jany, L.; Nisperos, A.; Bayles, J., Editors, 18-28 pp, 1996.

portland cement; clinker; phase composition; quantitative analysis; qualitative analysis; whole-pattern fitting; x-ray powder diffraction

X-ray powder diffraction is a direct method for qualitative and quantitative phase abundance analysis of fine-grained, crystalline materials. While the application of powder diffraction for qualitative analysis in the cement industry is well established, its use in the determination of phase abundance is not as common. Difficulty in measurement of peak intensity and availability of suitable reference standards have limited the application of x-ray diffraction in quantitative analysis. Whole-pattern fitting offers a means to address these problems by using all diffraction peaks to estimate individual phase pattern intensities. Dataplot, a graphics and data analysis language, facilitates pattern-fitting and quantitative phase abundance analyses by applying multivariate linear least-squares regression based upon experimentally derived x-ray diffraction reference patterns. Phase abundance calculation by the internal standard method uses the pattern scale factors calculated in the fit as intensity values. Precision of replicate analyses by pattern fitting show a distinct improvement over measurement by peak profile fitting. Trials using known mixtures of clinker interstitial phases indicate a very good agreement with the known phase abundance values, and absolute errors, based on the whole cement, of less than 1 percent.

Sunder, S. S.; Cranmer, D. C.; Korchak, R.
Manufacturing Extension Partnerships for the Construction Industry.
National Institute of Standards and Technology, Gaithersburg, MD
Construction Business Review, 1-6, 1996.

construction; manufacturing; industries

Construction is one of the nation's largest industries and a critical asset for enhancing the international competitiveness of U.S. industry. In 1994, the combined value of new construction, renovation, maintenance and repair was about $847 billion, representing 13 percent of the gross domestic product, and the industry provided 10 million jobs.

T

Tartarini, P.; diMarzo, M.
Dropwise Evaporative Cooling Radiative Field.
Universita di Bologna, Italy
Maryland Univ., College Park
NIST-GCR-96-687; Paper 10; 14-TP-23; June 1996.
Available from National Technical Information Service
PB96-202304

water sprays; evaporation cooling; solid surfaces; droplets; formulation; equations

This paper investigates the evaporative cooling of solid surfaces induced by the impingement of single water droplets. The solid surface is heated by radiant panels from above; therefore, the radiant heat absorbed directly by the evaporating droplet has to be considered. A theoretical model is presented, which calculates the droplet evaporation time and the solid surface cooling for materials with thermal magnitude. In particular, results concerning droplet evaporation on Macor (low thermal conductivity material) are reported and discussed. The model accurately predicts the total evaporation time. It is further validated with transient surface temperature measurements obtained by infrared thermography. The predictions are in excellent agreement with the experimental data. The interfacial heat flux distribution under the evaporating droplet is studied. These single droplet results are currently being used to study the basis for the formulation of a multi-droplet comprehensive model.

Tartarini, P.; diMarzo, M.
Mixed Numerical Scheme Solution for Dropwise Evaporative Cooling.
Universita di Bologna, Italy
Maryland Univ., College Park
NIST-GCR-96-687; Paper 8; June 1996.
Available from National Technical Information Service
PB96-202304

water sprays; evaporation cooling; solid surfaces; droplets; evaporation; thermal conductivity; equations; formulations

A numerical code for the prediction of evaporative cooling of solid surfaces induced by a gently deposited water droplet is presented. The code is based upon a solid-liquid coupled model which predicts the droplet evaporation and the solid surface cooling for materials with thermal conductivity spanning over more than two orders of magnitude. The numerical solution of the conduction equation, which links a control volume method (CVM) used for the liquid and a boundary element method (BEM) used for the solid, is presented. The necessity of using the BEM for the solid domain is particularly stressed.

Taylor, A. W.
Report of a Workshop on Requalification of Tubular Steel Joints in Offshore Structures. September 5-6, 1995. Houston, Texas.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5877; 100 p. June 1996.
Available from National Technical Information Service
PB96-210760

steel joints; offshore platforms; systems engineering; tubular joints

This report is a summary of a workshop titled "Requalification of tubular Steel Joints in Offshore Structures," held September 5 and 6, 1995 in Houston, Texas. the workshop was sponsored by the U.S. Minerals Management Service, and the National Institute of Standards and Technology. This report contains the papers presented at the workshop, a summary of the workshop discussions, and the conclusions reached by the workshop participants. The major issues discussed at the workshop included tubular joint characterization, computational methods, tubular joint failure definition/condition,condition assessment, and code requirements/technologytransfer. Needed technology developments included the following: improved methods for describing analytically the monotonic and cyclic behavior of joints, possibly through joint macro-models; improved methods for predicting the tensile fracture failure mode of joints; a coordinated effort to assess the body of available experimental data on tubular joints; investigation of elastic-plastic fracture mechanics applications to joints; cost/benefit studies prior to development of new analytical tools; a survey to determine the most important failure modes of joints; development of probabilistic approaches to condition assessment of joints; methods for characterizing the condition of new joints; improved methods for detecting flaws in existing joints; studies of the necessary scope and frequency of inspections of joints; improved code provisions for rating the ultimate strength of joints; improved code provisions for the use of actual steel strengths in evaluating existing joints; code provisions for evaluation of damaged joints; a definitive study of can lengths in K-joints; improved classification schemes for joints in terms of the ovalizing parameter a; and methods of incorporating fracture mechanics into code provisions.

Taylor, A. W.; El-Bahy, A.; Stone, W. C.; Kunnath, S.
Effect of Load Path on Damage to Concrete Bridge Piers.
National Institute of Standards and Technology, Gaithersburg, MD
University of Central Florida, Orlando
NIST SP 904; August 1996.

U.S./Japan Natural Resources Development Program (UJNR). Wind and Seismic Effects. Joint Meeting of the U.S./Japan Cooperative Program in Natural Resources Panel on Wind and Seismic Effects, 28th. May 14-17, 1996, Gaithersburg, MD, Raufaste, N. J., Editor, 149-158 pp, 1996.
Available from Government Printing Office
SN003-003-03424-0
Available from National Technical Information Service
PB97-104376

bridges (structures); bridge columns; building technology; damage modeling; earthquake engineering; laboratory testing; random loading; reinforced concretes

In earthquake engineering studies of reinforced concrete (RC) bridge columns, a controlled, cyclic lateral load pattern with gradually increasing amplitude has traditionally been applied to laboratory test specimens. However, in actual earthquakes bridge columns are exposed to random cyclic lateral loading patterns, which are much different from typical laboratory loading patterns. Current American Association of State Highway and Transportation Officials (AASHTO) and California Department of Transportation (Caltrans) design provisions are based almost entirely on tests in which traditional, controlled laboratory loading patterns have been applied. The differences in the effects of these types of loading have never been explored systematically. In this study both types of loading (controlled, cyclic lateral loads, and random earthquake type loads) were applied to a series of twelve nominally identical, one-fourth scale circular, cantilever columns, and the differences in observed damage were studied. In this paper the experimental results are briefly summarized, and preliminary findings are discussed.

Taylor, A. W.; Shenton, H. W., III; Chung, R. M.
Standards for the Testing and Evaluation of Seismic Isolation Systems.
National Institute of Standards and Technology, Gaithersburg, MD
University of Delaware, Newark
ASME/JSME Pressure Vessels and Piping Conference. Proceedings. Volume 319. July 23-27, 1995, Honolulu, HI, 39-43 pp, 1995.

base isolation; building technology; earthquake engineering; elastomeric bearings; evaluation; seismic design; sliding systems; standards; guidelines; tests

Draft guidelines for the testing and evaluation of seismic isolation systems have recently been developed at the National Institute of Standards and Technolgoy (NIST). These guidelines are organized into three sections: pre-qualification, prototype, and quality control testing. The guidelines are broadly applicable, since they are independent of the type of isolation system and superstructure. The guidelines will serve as a resource document for industry, and as basis for developing future standards for testing of isolation systems. This paper gives an overview of the NIST draft guidelines, emphasizing the philosophy behind the development of the guidelines. A brief summary of the contents of the guidelines is also present.

Tinker, S. C.; diMarzo, M.
Effect of Dissolved Gasses on Spray Evaporative Cooling With Water.
Maryland Univ., College Park
NIST-GCR-96-687; Paper 16; June 1996.
Available from National Technical Information Service
PB96-202304

water sprays; evaporative cooling; water; solid surfaces; droplets; hot surfaces; drop sizes; size distributions; experiments; data processing

An experimental investigation of the effect of non-degassed water used to cool a solid surface is presented. The solid surface is subjected to thermal radiant input from three panels positioned above it. The water is deposited on the surface in the form of a sparse spray with droplets of about 10 ml. Previous experiments with degassed water are compared with these new experiments and the effect of dissolved gasses is quantified in terms of the overall transient thermal behavior of the solid. A

lower steady-state average temperature is achieved when gasses are not removed from the water. This result suggests that the configuration of the liquid droplets on the surface is different and that the radiant heat input into the droplet is altered by the gas bubbles present in the deposited droplet. This information provides guidance in practical applications such as sprinkler suppression systems where water damages are a concern.

Tsongas, G. A.; Thornton, B. A.; Burch, D. M.; Walton, G. N.
Computer Analysis of the Moisture Performance of Roof Constructions in the U.S. DOE Moisture Control Handbook.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5919; 56 p. December 1996.
Available from National Technical Information Service
PB97-132088

air flow; attics; building codes; building research; guidelines and practices; mathematical analysis; mathematical models; moisture; moisture analysis; moisture control; moisture modeling; mold; mildew; roofs; roof cavities; roof ventilation; attic ventilation; site-built housing

A new mathematical model, called the MOIST Attic Model, that predicts the transfer of heat and moisture in ventilated or unventilated roof cavities is presented. The model includes both molecular diffusion and capillary transfer within the materials and also calculates the indoor relative humidity, the ceiling air leakage rate, and the roof cavity ventilation rate at hourly time steps. This computer simulation model can be used to assess the moisture performance of open attics as well as cathedral ceilings. Typical applications include estimating the variation throughouta year of the moisture content of roof wood members, of roof cavity surface relative humidities, and of ceiling heat flux. In the present study, the model is used to predict the moisture performance of a current practice site-built prototype house with 15 different roof designs constructed in compliance with the "U.S. DOE Moisture Control Handbook" in cold (heating), mixed, and cooling (hot and humid) climates. These open attic or cathedral ceiling roof constructions were intended to be the best designs to minimize moisture accumulation, thereby preventing material degradation, mold and mildew growth, and loss in thermal performance. But prior to this study, their moisture performance had not been checked with a moisture model. Thus this computer simulation study of their performance was undertaken. For each of the 15 roof designs, attention was focused on the peak values of the plywood roof sheathing moisture content and the relative humidity at the bottom of the insulation adjacent to the various ceilings where mold and mildew might grow. Findings of the study regarding the moisture performance of the 15 designs, as well as roof design suggestions, are presented along with recommendations for further study.

V

Vallikul, P.; Goulard, R.; Mavriplis, C.; Nyden, M. R.
Tomographic Reconstruction of Probability Density Functions in Turbulent Flames.
George Washington Univ., Washington, DC
National Institute of Standards and Technology, Gaithersburg, MD
Interscience Communications Ltd.; National Institute of Standards and Technology; Building Research Establishment; and Society of Fire Protection Engineers; Swedish National Testing and Research Institute. Interflam '96. International Interflam Conference, 7th Proceedings. March 26-28, 1996, Cambridge, England, Interscience Communications Ltd., London, England, Franks, C. A.; Grayson, S., Editors, 235-243 pp, 1996.

fire safety; smoke measurement; turbulent flames; density effects; algorithms

Local probability density functions (PDF) of absorption coefficients within turbulent flames have been retrieved from their multi-angular absorption data of path-integrated probability density functions via a series of numerical techniques. First the Filter Back-Projection (FBP) technique has been used to reconstruct local moments within the flame then the moments are transformed to the local PDFs by using the singular value decomposition (SVD) technique. The FBP technique transforms the absorption data into the frequency domain where noisy components can be truncated while turbulent components are still preserved in the form of reconstructed moments. The reconstruction algorithm is tested by using both synthetic and experimental absorption data. Reconstruction from synthetic data allows the reconstruction algorithm to be evaluated independently of path measurement noise. On the other hand, reconstruction from experimental data demonstrates the capability of determining the local PDF analytically within the turbulent flame. Good reconstruction results are obtained from both cases and the reconstruction algorithm is justified.

Vandsburger, U.; Roby, R. J.
Dynamics, Transport and Chemical Kinetics of Compartment Fire Exhaust Gases. Annual Report. September 1994-September 1995.
Virginia Polytechnic Institute and State Univ., Blacksburg
Hughes Associates, Inc., Baltimore, MD
NIST-GCR-96-688; 75 p. June 1996.
Available from National Technical Information Service
PB96-195508

exhaust gases; compartment fires; air entrainment; combustion gases; carbon monoxide; corridors; fire research; large scale fire tests; hydrocarbons; pool fires; toxic gases; reaction kinetics

The investigation focuses on the transport of carbon monoxide (CO) away from a burning compartment and the conditions necessary for the existence of fatally high concentrtions of CO at remote locations. The study is conducted at the Building Fire Research Laboratory at Virginia Tech. During the past year, the research has concentrated on the transport of CO away from a reduced-scale burning compartment located on the side of the end of a hallway. High levels of CO were transported to remote locations by limiting the air entrainment into the plume of compartment fire gases entering the hallway. In experiments with limited plume air entrainment and external burning high levels of CO (2.5-2.8%-wet) were measured exiting the compartment and at locations across the hallway. High levels of CO (1.6-2.4%-wet) were also measured in the gases moving down the side of the hallway opposite the compartment, while low levels of CO (0.4-1%-wet) were measured in gases along the compartment side of the hallway. External burning resulted in the oxidation of mostly unburned hydrocarbons (UHC), with only 0.5% measured exiting the hallway. The non-uniform transport of combustion gases down the hallway explains the locations of fatalities in previously reported fires.

VanRickley, C. W.
Survey of Code Officials on Performance-Based Codes and Risk-Based Assessment.
Van Rickley and Associates, San Diego, CA
Codes Forum, 42-43,45-46, January/February 1996.

codes; risk assessment; decision making; surveys

A survey was administered at the 1995 annual conference of BOCA (Building Officials and Code Administrators), ICBO (International Conference of Building Officials) and SBCCI (Southern Building Code Congress International). The survey was structured to estimate the status of performance-based codes and risk-based analysis. There is a need to develop codes that contribute to reducing the building construction time and maintaining acceptable levels of life safety. Further investigation is needed to determine where the building and fire officials believe performance-based codes will fit into their requirements to provide reasonable levels of fire protection and life safety. A need exists to review existing computer fire-prediction models and to develop and validate additional models to support the designs and concepts that will be developed through performance-based building analysis. The models must be usable by both design professionals and code enforcement personnel.

Venkatesh, S.; Ito, A.; Saito, K.
Why are Pool Fires Anchored?
Kentucky Univ., Lexington
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 37-38 pp, 1996.
Available from National Technical Information Service

fire research; fire science; pool fires; flow visualization

This paper attempts to answer the question, "Why are small scale pool fires anchored?" by providing and interpreting a new set of experimental data. For momentum-controlled, high Reynolds (Re) number turbulent-jet diffusion flames, the formation of a premixing zone is suggested as the primary reason for the flame anchoring. For buoyancy-controlledpool fires, however, the existence of the premixing zone at the flame base is not clear because both Re and Fr (Froude number) are low. To improve our understanding of the flame anchoring mechanism and structure of buoyancy-controlled liquid pool fires, we employed small scale pool fires whose diameters range between 1.5 - 20 cm. Our measurements include flow visualization by a particle-trace laser-sheet technique (PTLS) combined with a high speed video camera and temperature profiles by a fine thermocouple. We found from those measurements that major air entrainment occurred through the primary anchoring zone, PAZ, which consists of a small area covering approximately 1 cm high and around the circumference just above the dark zone; while air entraiment through the quenching zone (a dark zone formed between the visible flame edge and the burner port) was negligible. The structure of the PAZ was found to be premixed flame (another interpretation may be it is similar to counter-diffusion flame). This enables the pool fires to anchor at the burner port. In addition, we visualized the existence of a vortex ring at a stagnation zone in the fuel vapor phase for both propanol and hexane pool fires, in agreement with qualitative observation by other workers.

Venkatesh, S.; Ito, A.; Saito, K.; Wichman, I. S.
Flame Base Structure of Small-Scale Pool Fires.
Kentucky Univ., Lexington
Michigan State Univ., East Lansing
NIST-GCR-96-704; 59 p. December 1996.
Available from National Technical Information Service

pool fires; air entrainment; diffusion flames; flame spread; flow visualization; small scale fire tests; temperature profiles

This paper attempts to answer the question, "Why are small scale pool fires anchored?" by providing and interpreting a new set of experimental data. For momentum-controlled, high Reynolds (Re) number turbulent-jet diffusion flames, the formation of a premixing zone is suggested as the primary reason for the flame anchoring. For buoyancy-controlledpool fires, however, the existence of the premixing zone at the flame base is not clear because both Re and Fr (Froude number) are low. To improve our understanding of the flame anchoring mechanism and structure of buoyancy-controlled liquid pool fires, we employed small scale pool fires whose diameters range between 1.5 - 30 cm. Our measurements include flow visualization by a particle-track laser-sheet technique (PTLS) combined with a high speed video camera and temperature profiles by a fine thermocouple. We found from those measurements that major air entrainment occurred through the primary anchoring zone, PAZ, which consists of a small area covering approximately 1 cm high and around the circumference just above the dark zone; while air entrainment through the quenching zone (a dark zone formed between the visible flame edge and the burner port) was negligible. The structure of the PAZ was found to be premixed flame (another interpretation may be it is similar to counter-diffusion flame). This enables the pool fires to anchor at the burner port. In addition, we visualized the existence of a vortex ring at a stagnation zone in the fuel vapor phase for both propanol and hexane pool fires, in agreement with qualitative observation by other workers.

W

Wade, R. W.; Gore, J. P.
Visible and Chemical Flame Lengths of Acetylene/Air Jet Diffusion.
Purdue Univ., West Lafayette, IN
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 41-42 pp, 1996.
Available from National Technical Information Service

fire research; fire science; diffusion flames; jet flames; flame length; acetylene; air; turbulent flames

The lengths of turbulent diffusion flames have been widely studied experimentally and theoretically. Flame lengths are typically defined in terms of the mean temperature, chemical composition or luminosity along the axis. For many flames, the interchangeable use of the different definitions, that frequently occurs in the literature, may cause qualitative and quantitative discrepancies amongst data and confusion regarding the importance of different physical processes. There are several existing models for flame length correlations. The significant assumption in most of the flame length correlation is that the visible flame length is proportional to local chemical state. One complication that these existing models do not address is that of soot. If a large fraction of the fuel mass is converted to soot, then the visible flame length would be determined by radiation emitted by the hot soot particles. The radiation transferred from the hot soot particles to the surroundings lowers that temperature of the soot and flame gas mixtures making the flame non-luminous. Gore et al. have shown that the peak temperature along the centerline occurs much closer to the injector exit in strongly radiating flames than in weakly radiating flames. Therefore, the definition of flame length based on this visible luminosity is inconsistent. Based on the above, the objective of the present work was to obtain flame lengths based on measurements of axial gas species concentrations.

Walton, G. N.
CONTAM94: A Multizone Airflow and Contaminant Dispersal Model With a Graphic User Interface.
National Institute of Standards and Technology, Gaithersburg, MD
Performance Simulation Association. Building Simulation '95. 4th Conference. Proceedings. August 14-16, 1995, Madison, WI, 1-6 pp, 1995.

computer simulation; computer programs; multizone building; air flow; indoor air quality; contaminants

CONTAM94 is an easily used, public domain airflow and contaminant migration analysis program combining algorithms for modeling airflow and contaminant dispersal in multizone buildings. It employs a simplified graphic description of the building for both data entry and the presentation of simulation results. It runs on commonly available 486DX class PC compatible computers with VGA graphics and MS-DOS. It can handle buildings containing a large number of zones.

Walton, W. D.; McGrattan, K. B.; Mullin, J. V.
ALOFT-PC: A Smoke Plume Trajectory Model for Personal Computers.
National Institute of Standards and Technology, Gaithersburg, MD
Minerals Management Service, Herndon, VA
Environment Canada. Arctic and Marine Oilspill Program (AMOP) Technical Seminar, 19th. Volume 2. Proceedings. June 12-14, 1996, Alberta, Canada, Enviornment Canada, Ottawa, Ontario, 987-997 pp, 1996.

oil spills; in situ burning; computer models; heat release rate; crude oil; plumes; pool fires; wind velocity; temperature profiles

As the understanding of the capabilities and limitations of in situ burning of oil spills increases, in situ burning continues to gain acceptance as an oil spill mitigation tool. One widely imposed criteria for the use of in situ burning is limiting the exposure of downwind populations to smoke particulate. Since the downwind distribution of smoke particulate is a complex function of the fire parameters, meteorological conditions, and topographic features, a computer based model is required to predict the smoke plume trajectory. Measurements and observations at experimental burns have shown that the downwind distribution of smoke is not Gaussian and simple smoke plume models do not capture the observed plume features. To resolve these problems, NIST has developed a smoke plume trajectory model that solves the fundamental Navier-Stokes equations using an eddy viscosity over a uniform grid which spans the smoke plume and its surroundings. This large eddy simulation smoke plume model has been refined over a period of years using a computer workstation and the results have compared favorably with the limited data available from experimental burns. ALOFT-PC (A Large Open Fire plume Trajectory model) is the public domain version of the model for windows based personal computers. The model inputs include wind speed and variability, atmospheric temperature profile, and fire parameters and the output is the average concentration of smoke in each of the computational cells from ground level to the top of the plume. ALOFT-PC is designed to aid in the in situ burn planning process. For this purpose a "foot print" of the ground level smoke concentration is the most commonly used model output.

Walton, W. D.; Putorti, A. D., Jr.; Twilley, W. H.; Albers, J. C.
Santa Ana Fire Department Experiments at South Bristol Street.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5776; 218 p. February 1996.
Available from National Technical Information Service
PB96-154810

bedrooms; fire tests; furniture; home fires; single family dwellings; smoke detectors; sprinklers; temperature measurements; experiments

A series of fire experiments were conducted in vacant single family dwellings on South Bristol Street in Santa Ana, California. Fire experiments were conducted in bedrooms and living rooms. Fuels consisted of either home furnishings or a propane burner. Fire phenomena measured included: temperatures within various rooms, wall jet velocity, fuel mass during burning, heat flux smoke detector activation time, sprinkler activation time, oxygen concentration, and time to full room involvement.

Weber, S. F.
AutoBid 2.0: The Microcomputer System for Police Patrol Vehicle Selection.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5787; Project NIJ95-008; 10 p. February 1996.
Available from National Technical Information Service
PB96-154570

acquisition decisions; fleet administration; microcomputers; multi-attribute decisions; performance ranking; police patrol vehicles; police equipment; optimization; software; vehicles

This report is the user manual for a microcomputer system designed to help police fleet administrators select the patrol vehicle that is best suited to their needs. The system is called AutoBid and uses vehicle performance test data for police patrol package models published annually by the Michigan State Police. The system offers two vehicle selection methods: performance-based and value-based. Performance selection is based on vehicle test scores alone. It ranks vehicles by their overall test performance independent of cost. Value selection is based on both vehicle cost and test scores. It identifies which vehicle is the "BestBuy" in terms of the lowest cost for equivalent test performance and ranks the vehicles by the bid price adjusted for performance. Either or both of these methods may be used for a given fleet acquisition decision. Help screens explaining both the underlying concepts as well as how to use the software are available throughout the program. AutoBid runs on an MS-DOStm microcomputer with at least 512 kilobytes of RAM. It may be run from a floppy drive or it may be installed on a hard drive.

Weber, S. F.; Lippiatt, B. C.
Cost-Effective Compliance With Life Safety Codes.
National Institute of Standards and Technology, Gaithersburg, MD
Fire Technology, Vol. 32, No. 4, 291-296, November/December 1996.

life safety codes; cost effectiveness; building codes; building economics; economic analysis; fire safety; health care facilities; hospitals; linear programming; mathematical programming; optimization

ALARM is personal computer software that helps building managers and fire safety engineers achieve cost-effective compliance with the widely used NFPA 101, Life Safety Code. The software currently supports health-care occupancy analysis. Through the equivalency provision of the code, ALARM implements a goal-oriented, or performance-based, approach to code compliance. The software generates a set of alternative code compliance strategies and their estimated construction costs. Engineering judgment is then applied to select the most appropriate code compliance strategy based on both cost and design considerations. The software offers a code-compliance optimizer, a comprehensive file manager, and a full-screen data editor. Since 1981, the optimization method used in ALARM has been field-tested data editor. Since 1981, the optimization method used in ALARM has been field-tested in 89 hospitals (17,898 beds). For this sample, the least-cost solution identified by the software was, on average, 41 percent less expensive than the prescriptive solution. This represents a potential cost savings of $2,116 per bed or more than $37 million. Future versions of ALARM could address other building occupancies.

Whalen, T. M.
Probabilistic Estimates of Design Load Factors for Wind-Sensitive Structures Using the "Peaks Over Threshold" Approach.
National Institute of Standards and Technology, Gaithersburg, MD
NIST TN 1418; 30 p. April 1996.
Available from Government Printing Office

building technology; building codes; climatology; extreme value theory; hurricanes; load factors; structural engineering; structural reliability; threshold methods; wind (meteorology)

The "peaks over threshold" method is used to estimate ratios of wind-induced loads with various long mean recurrence intervals to loads with a 50-year mean recurrence interval. The results support the conclusion that the load factor value of 1.3 specified in the ASCE Standards 7-93 and 7-95 is adequate for extratropical storm regions. However, for hurricane-prone regions, the results imply that the standard value of the load factor (even after being augmented by an importance factor specified in the standards) leads to nominal ultimate wind loads with considerably shorter mean recurrence intervals than is the case for extratropical regions. This suggests that the 1.3 load factor value specified in the ASCE Standards 7-93 and 7-95 is inadequate for wind-sensitive structures in hurricane-prone regions.

Womeldorf, C. A.
Refrigerant Flammability: A New Application of the Opposed-Flow Burner.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 145-146 pp, 1996.
Available from National Technical Information Service

fire research; fire science; refrigerants; flammability; burners

Due to concerns about the impact of cholorofluorocarbons(CFCs) on the earth's ozone, new refrigerants are being evaluated by the air-conditioningand refrigerant industry to identify environmentally friendly replacements. These alternative refrigerants are primarily hydrofluorocarbons(HFCs) and hydrochlorofluorocarbons(HCFCs); some of which, because of the additional hydrogen atoms, are flammable. In order to maintain the current requirement of non-flammable refrigerants, optimized

mixtures which maximize efficiency while minimizing risk are desired. Current methods of measuring of flammability for weakly flammable refrigerants have a large uncertainty and produce results which require operator interpretation. This work presents an alternative approach with reduced uncertainty and less operator interpretation.

Woycheese, J. P.; Pagni, P. J.
Brand Lofting in Large Fire Plumes.
California Univ., Berkeley
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 67-68 pp, 1996.
Available from National Technical Information Service

fire research; fire science; fire plumes; urban fires; fire spread; fire brands

Urban/wildland intermix conflagrations occur when dry vegetative fuels of the wild areas combine with structural fuels from houses to product a combustible environment that, once ignited, easily becomes uncontrollable. The dominant mechanism for propagation of these fires is the copious fire brands these fuels produce. This research is a first step in the development of a modular model for fire growth in the urban/wildland intermix. The goal is to predict the area that is at risk from brand-induced fire spread during a large conflagration. Our work expands that performed by Tarifa, et al., substituting a more realistic plume velocity field based on the Baum and McCaffrey plume model for the constant plume velocity assumed there.

Wright, R. N.
Performance Approach to Construction Goals.
National Institute of Standards and Technology, Gaithersburg, MD
Applications of the Performance Concept in Building.
CIB-ASTM-ISO-RILEM 3rd International Symposium. Volume 2. Proceedings. National Building Research Institute. December 9-12, 1996, Tel-Aviv, Israel, National Building Research Inst., Haifa, Israel, 2/1-10 pp, 1996.

construction; constructed facilities; construction goals; performance approach; performance concept; performance standards

The performance approach, because it focuses directly and intelligently on the qualities desired of constructed facilities and enables innovation, is essential to the quality and economy of constructed facilities and the competitiness of the industries of construction. Construction goals, expressing the benefits of improved performance, attract the attention and support of policy makers in the private and public sectors that is needed to focus and fund the research, development and deployment efforts required to achieve the goals. Collaborations in the United States between leaders of the industries of construction and federal agencies responsible for construction- related research and practice have led to formulation of construction goals and the program of performance-oriented R&D required to achieve the goals. Since both the needs for improved construction practices and the enabling technologies are internationally relevant, there are important opportunities for international collaborations in the funding and conduct of performance-oriented R&D addressing construction goals.

Wright, R. N.
Workshop Introduction.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5856; May 1996.
National Institute of Standards and Technology. NIST Construction Automation Program, Report No. 2. NIST Construction Automation Workshop. Proceedings. Chapter One: Topical Lectures. Paper 1.1. March 20-31, 1995, 1-10 pp, 1995.

Available from National Technical Information Service
PB96-202239

building construction; industries

Let me take this opportunity to welcome each of you to NIST and to Gaithersburg, Maryland. I would like to take this opportunity to present some information on recent developments concerning federal research and development funding, some of which pertains to work being discussed here today.

Wu, J. S.; Krishnan, S. K.; Lin, K. C.; Faeth, G. M.
Refractive Indices of Overfire Soot in Large Buoyant Turbulent Diffusion Flames.
Michigan Univ., Ann Arbor
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 25-26 pp, 1996.
Available from National Technical Information Service

fire research; fire science; soot; turbulent flames; diffusion flames

Information about the optical properties of soot is needed in order to develop reliable nonintrusive measurements of soot physical properties and estimates of soot radiation properties in flame environments. Unfortunately, current estimates of soot optical properties are limited by excessive uncertainties about soot refractive indices. Motivated by this observation, the objective of the present investigation was to experimentally determine soot refractive indices at visible wavelengths (350-800 nm). Soot in the overfire region of buoyant turbulent diffusion flames in the long residence time regime (where soot properties are independent of position and residence time) was studied, considering flames fueled with acetylene, propylene, ethylene and propane burning in still air.

Y

Yang, J. C.; Boyer, C. I.; Grosshandler, W. L.
Minimum Mass Flux Requirements to Suppress Burning Surfaces With Water Sprays.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5795; 50 p. April 1996.
Available from National Technical Information Service
PB96-183181

drop sizes; extinguishment times; fire suppression; mist; sprays; polymethyl methacrylate; polystyrene foams; wood

Experimental measurements of extinguishment times of burning solid fuels using water were conducted using a prototype micronozzle array and a piezoelectric droplet generator. Solid fuels considered included solid white pine, polymethylmethacrylate, and polystyrene foam. External heat flux was applied to the sample surface during burning. The effects of drop size, sample orientation with respect to the nozzle, and nozzle distance from the sample surface on extinguishment time were examined. The extinguishment time was found to decrease with increasing water flow rate. For a given water flow rate, significant reduction in extinguishment time was observed when smaller droplets were used. At low water flow rates, the extinguishment time decreased when the nozzle was positioned further from the sample surface. At high flow rates, the extinguishment was independent of the nozzle-to-sample distance. When the droplet stream was 45DG relative to the sample, the extinguishment time was not affected by the nozzle-to-sample distance. The other component of the project was to evaluate a commercial low pressure, high momentum pendant water mist nozzle using an optical array probe droplet analyzer. The pendant nozzle used in this study is currently being evaluated by listing organizations for fire suppression in residential and light hazard occupancies. The objective of this study was to determine drop size and velocity distributions at various locations

in the spray. Experiments were conducted at delivery pressures of 621 kPa + 14 kPa (90.0 psi + 2.0 psi) and 448 kPa + 14 kPa (65.0 psi + 2.0 psi). The droplet diameters from the experiments were found to range from less than 36 mm to 1230 mm for the experiments conducted at 448 kPa + 14 kPa (65.0 psi + 2.0 psi,) and to range from less than 36 mm to 1155 mm for the experiments conducted at 621 kPa + 14 kPa (90.0 psi + 2.0 psi). The velocities of the water droplets were calculated based on the time required for each individual drop to pass through the probe image field. The range of droplet velocities was found to be approximately 0.19 m/s to 1.58 m/s (0.62 ft/s to 5.18 ft/s) from the experiments conducted at 448 kPa + 14 kPa (65.0 psi + 2.0 psi). For the measurements taken at 621 kPa + 14 kPa (90.0 psi + 2.0 psi), the droplet velocities ranged from approximately 0.25 m/s to 1.9 m/s (0.82 ft/s to 6.23 ft/s).

Yang, J. C.; Hamins, A.; Gorchkov, N. N.; Glover, M.
Combustion of Polymethylmethacrylate Spheres at Normal and Reduced Gravity.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 135-136 pp, 1996.
Available from National Technical Information Service

fire research; fire science; polymethyl methacrylate; gravity; combustion; experiments

Polymer combustion is a highly complicated process where chemical reactions may occur not only in the gas phase, but also in the condensed phase as well as at the solid-gas interphase. The complication arises due to the coupling between the condensed phase and gas phase phenomena. While some polymers form a char layer during combustion, others exhibit swelling, bubbling, melting, sputtering, and multi-stage combustion. The combustion of polymeric materials is related to many applications including solid and hybrid rocket propulsion, and of recent interest, waste incineration.

Yang, J. C.; Pitts, W. M.; Breuel, B. D.; Grosshandler, W. L.; Cleveland, W. G.
Rapid Discharge of a Fire Suppressing Agent.
National Institute of Standards and Technology, Gaithersburg, MD
International Communications in Heat and Mass Transfer, Vol. 23, No. 6, 835-844, 1996.

discharge rate; halon alternatives; mathematical models; pressure vessels; high speed photography

This paper describes an experimental method to study the rapid discharge of a fire suppressant (C3F8) from a pressurized vessel. Experimental observations inside and at the exit of the vessel were made using high-speed photography Boiling was not observed inside the vessel during discharges. A simple mathematical model was developed to predict the liquid depletion level and is compared to the experimental measurements.

Z

Zarr, R. R.; Davis, M. W.; Anderson, E. H.
Room-Temperature Thermal Conductivity of Expanded Polystyrene Board for a Standard Reference Material.
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5838; 42 p. May 1996.
Available from National Technical Information Service

PB96-193639

expanded polystyrene; thermal conductivity; calibration; fenestration; foam; guarded hot plate; standard reference materials

Thermal conductivity measurements at room temperature are presented as the basis for certified values of SRM 1453, expanded polystyrene board. The measurements have been conducted in accordance with a randomized full factorial experimental design with two variables, bulk density and temperature, using NIST's one-meter line-heat-source guarded hot plate apparatus. Uncertainties of the measurements, consistent with current ISO guidelines, have been prepared. The thermal conductivity measurements were conducted over a range of bulk density of 37.4 to 45.8 kg/m3 and mean temperature of 281 to 313 K. Statistical analyses of the physical properties of the SRM are presented and include variations between boards, as well as within boards. Measurements of the foam's compressive properties and microstructure are presented.

Zarr, R. R.; Hahn, M. H.
Line-Heat-Source Guarded-Hot-Plate Apparatus.
National Institute of Standards and Technology, Gaithersburg, MD
ASTM Designation C1043; PCN 12-310430-61; 33 p. 1996.

guarded hot plate; line heat source; heat insulators; test methods

This adjunct describes the line-heat-source guarded-hot-plate apparatus fabricated by the National Institute of Standards and Technology. It is intended as a guide in the design and construction of a guarded hot plate having circular line heat sources. The essential requirements for steady-state testing of heat insulators are described in ASTM Test Method C 177 and the essential requirements for the design of guarded hot plates having circular line-heat-sources are covered in ASTM Practice C 1043.

Zhou, X. C.; Gore, J. P.; Baum, H. R.
Measurements and Prediction of Fire Induced Flow Field.
Purdue Univ., West Lafayette, IN
National Institute of Standards and Technology, Gaithersburg, MD
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 77-78 pp, 1996.
Available from National Technical Information Service

fire research; fire science; flow fields; entrainment; pool fires; methanol; heptane; toluene

Motivated by the various application of entrainment rate correlations in fire research and the large uncertainity in the efficacy of existing correlations and experimental data, the first particle Imaging Velocimetry (PIV) based measurements of fire induced flow field around pool fires burning methanol, heptane and toluene were obtained. Air entrainment rates for 15 cm and 30 cm pool fires burning the three different fuels were calculated based on the mean velocity field. The entrainment data for the six fires could be correlated well using the fire Froude number, defined in Ref. 1 as the nondimensional parameter. A kinematic approach for the prediction of the fire induced flow field, following Ref. 2, was extended to the present fires. The driving processes for the entrainment flow, namely the volumetric heat release and the baroclinic vorticity generation, were evaluated based on correlations of buoyant diffusion flame structure in the literature. The predicted entrainment velocities were substantially higher than the measurements but were in qualitative agreement with the data. Based on this, the heat release rate and vorticity correlations used in the analysis were corrected by using a smaller radius for the 1/e point in the elocity profile. The modified predictions were in better agreement with the experimental data. Therefore, further evaluation of the kinematic approach with proper heat release rate and vorticity distributions is warranted.

Zukoski, E. E.
Scaling Flame Lengths of Large Diffusion Flames.
California Institute of Technology, Pasadena, CA
NISTIR 5904; October 1996.
National Institute of Standards and Technology. Annual Conference on Fire Research: Book of Abstracts. October 28-31, 1996, Gaithersburg, MD, 39-40 pp, 1996.
Available from National Technical Information Service

fire research; fire science; diffusion flames; scaling laws; flame length

The scaling laws for flame length of large buoyant diffusion flames have not been established on any basis except simple correlations and the correct parameters to be used in these have not been clearly established. Several possible parameters are discussed and a set of experiments is described in which the effects on the flame length of changing these parameters are investigated. The changes in the parameters are accomplished by diluting natural gas fuel with nitrogen and by heating and diluting the ambient air with products of combustion.

2. AUTHOR INDEX

E

F

G

H

I

J

O

P

Q

R

S

T

V

W

Y

Z

3. KEYWORD INDEX

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

Q

R

S

T

U

V

W

X

Z

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